THE
POPULAR SCIENCE
MONTHLY.

DECEMBER, 1902.

THE HIGHER EDUCATION OF WOMEN.*

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THE subject of the higher training of young women may resolve itself into three questions:

1. *Shall a girl receive a college education?*
2. *Shall she receive the same kind of a college education as a boy?*
3. *Shall she be educated in the same college?*

As to the first question: It must depend on the character of the girl. Precisely so with the boy. What we should do with either depends on his or her possibilities. No parent should let either boy or girl enter life with any less preparation than the best he can give. It is true that many college graduates, boys and girls alike, do not amount to much after the schools have done all they can. It is true also that higher education is not a question alone of preparing great men for great things. It must prepare even little men for greater things than they would otherwise have found possible. And so it is with the education of women. The needs of the time are imperative. The highest product of social evolution is the growth of the civilized home, the home that only a wise, cultivated and high-minded woman can make. To furnish such women is one of the worthiest functions of higher education. No young women capable of becoming such should be condemned to anything lower. Even with those who are in appearance too dull or too vacillating to reach any high ideal of wisdom, this may be said—it does no harm to try. A few hundred dollars is not much to spend on an experiment of such moment. Four of the

* Abstract of an address before the Federation of Woman's Clubs, Los Angeles, May 5, 1902.

best years of one's life spent in the company of noble thoughts and high ideals cannot fail to leave their impress. To be wise, and at the same time womanly, is to wield a tremendous influence, which may be felt for good in the lives of generations to come. It is not forms of government by which men are made and unmade. It is the character and influence of their mothers and their wives. The higher education of women means more for the future than all conceivable legislative reforms. And its influence does not stop with the home. It means higher standards of manhood, greater thoroughness of training, and the coming of better men. Therefore let us educate our girls as well as our boys. A generous education should be the birthright of every daughter of the republic as well as of every son.

It is hardly necessary among intelligent men and women to argue that a good woman is a better one for having received a college education. Anything short of this is inadequate for the demands of modern life and modern culture. The college training should give some basis for critical judgment among the various lines of thought and effort which force themselves upon our attention. Untrained cleverness is said to be the most striking characteristic of the American woman. Trained cleverness, a very much more charming thing, is characteristic of the American college woman. And when cleverness stands in the right perspective, when it is so strengthened and organized that it becomes wisdom, then it is the most valuable dowry a bride can bring to her home.

Even if the four K's, 'Kirche, Kinder, Kuchen and Kleider,' are to occupy woman's life as Emperor William would have us believe, the college education is not too serious a preparation for the profession of directing them. A wise son is one who has had a wise mother, and to give alertness, intelligence and wisdom is the chief function of a college education.

2. *Shall we give our Girls the Same Education as our Boys?*

Yes, and no. If we mean by the *same,* an equal degree of breadth and thoroughness, an equal fitness for high thinking and wise acting, yes, let it be the same. If we mean this: Shall we reach this end by exactly the *same* course of studies? then the answer must be, No. For the same course of study will not yield the same results with different persons. The ordinary 'college course' which has been handed down from generation to generation is purely conventional. It is a result of a series of compromises in trying to fit the traditional education of clergymen and gentlemen to the needs of a different social era. The old college course met the needs of nobody, and therefore was adapted to all alike. The great educational awakening of the last twenty years in America has lain in breaking the bonds of this old system. The

essence of the new education is constructive individualism. Its purpose is to give to each young man that training which will make a man of *him*. Not the training which a century or two ago helped to civilize the mass of boys of that time, but that which will civilize this particular boy. The main reason why the college students of to-day are twenty times as many as twenty years ago is that the college training now given is valuable to twenty times as many men as could be reached or helped by the narrow courses of twenty years ago.

In the university of to-day the largest liberty of choice in study is given to the student. The professor advises, the student chooses, and the flexibility of the courses makes it possible for every form of talent to receive proper culture. Because the college of to-day helps ten times as many men as that of yesterday could hope to reach it is ten times as valuable. This difference lies in the development of special lines of work and in the growth of the elective system. The power of choice carries the duty of choosing rightly. The ability to choose has made a man out of the college boy and has transferred college work from an alternation of tasks and play to its proper relation to the business of life. Meanwhile the old ideals have not risen in value. If our colleges were to go back to the cut-straw of medievalism, to their work of twenty years ago, their professors would speak to empty benches. In those colleges which still cling to these traditions the benches are empty to-day, or filled with idlers.

I do not mean to condemn the study of the ancient classics and mathematics which made almost the whole of the older college course. These studies must always have their place, but no longer an exclusive place. The study of the language and literature of Greece still ranks with the noblest efforts of the human intelligence. For those who can master it Greek gives a help not to be obtained in any other way. As Thoreau once observed, those who would speak of forgetting the Greek are those who never knew it. But without mastery there is no gain of strength. To compel all men and boys of whatever character or ability to study Greek is in itself a degradation of Greek, as it is a hardship to those forced to spend their strength where it is not effective. There are other forms of culture better fitted to other types of man, and the essential feature lies in the strength of mastery.

The best education for a young woman is surely not that which has proved unfit for the young man. She is an individual as well as he, and her work gains as much as his by relating it to her life. But an institution which meets the varied needs of varied men can also meet the varied needs of the varied women. The intellectual needs of the two classes are not very different in many important respects. In so far as these are different the elective system gives full play for the expression

of such differences. It is true that most men in college look forward to professional training and that very few women do so. But the college training is not in itself a part of any profession, and it is broad enough in its range of choice to point to men and women alike the way to any profession which may be chosen. Those who have to do with the higher education of women know that the severest demands can be met by them as well as by men. There is no demand for easy or 'goody-goody' courses of study for women except as this demand has been encouraged by men. In this matter the supply has always preceded the demand.

There are, of course, certain average differences between men and women as students. Women have often greater sympathy or greater readiness of memory or apprehension, greater fondness for technique. In the languages and literature, often in mathematics and history, they are found to excel. They lack, on the whole, originality. They are not attracted by unsolved problems and in the inductive or 'inexact' sciences they seldom take the lead. The 'motor' side of their minds and natures is not strongly developed. They do not work for results as much as for the pleasure of study. In the traditional courses of study —traditional for men—they are often very successful. Not that these courses have a fitness for women, but that women are more docile and less critical as to the purposes of education. And to all these statements there are many exceptions. In this, however, those who have taught both men and women must agree; the training of women is just as serious and just as important as the training of men, and no training is adequate for either which falls short of the best.

3. *Shall Women be taught in the Same Classes as Men?*

This is partly a matter of taste or personal preference. It does no harm whatever to either men or women to meet those of the other sex in the same class rooms. But if they prefer not to do so, let them do otherwise. No harm is done in either case, nor has the matter more than secondary importance. Much has been said for and against the union in one institution of technical schools and schools of liberal arts. The technical quality is emphasized by its separation from general culture. But I believe that better men are made when the two are brought more closely together. The culture studies and their students gain from the feeling of reality and utility cultivated by technical work. The technical students gain from association with men and influences of which the aggregate tendency is toward greater breadth of sympathy and a higher point of view.

A woman's college is more or less distinctly a technical school. In most cases, its purpose is distinctly stated to be such. It is a school of training for the profession of womanhood. It encourages womanli-

ness of thought as more or less different from the plain thinking which is called manly. The brightest work in woman's colleges is often accompanied by a nervous strain, as though its doer were fearful of falling short of some outside standard. The best work of men is natural, is unconscious, the normal result of the contact of the mind with the problem in question.

In this direction, I think, lies the strongest argument for coeducation. This argument is especially cogent in institutions in which the individuality of the student is recognized and respected. In such schools each man, by his relation to action and realities, becomes a teacher of women in these regards, as, in other ways, each cultivated woman is a teacher of men.

In woman's education, as planned for women alone, the tendency is toward the study of beauty and order. Literature and language take precedence over science. Expression is valued more highly than action. In carrying this to an extreme the necessary relation of thought to action bcomes obscured. The scholarship developed is not effective, because it is not related to success. The educated woman is likely to master technique, rather than art; method, rather than substance. She may know a good deal, but she can do nothing. Often her views of life must undergo painful changes before she can find her place in the world.

In schools for men alone, the reverse condition often obtains. The sense of reality obscures the elements of beauty and fitness. It is of great advantage to both men and women to meet on a plane of equality in education. Women are brought into contact with men who can do things—men in whom the sense of reality is strong, and who have definite views of life. This influence affects them for good. It turns them away from sentimentalism. It gives tone to their religious thoughts and impulses. Above all, it tends to encourage action as governed by ideals, as opposed to that resting on caprice. It gives them better standards of what is possible and impossible when the responsibility for action is thrown upon them.

In like manner, the association with wise, sane and healthy women has its value for young men. This value has never been fully realized, even by the strongest advocates of coeducation. It raises their ideal of womanhood, and the highest manhood must be associated with such an ideal. This fact shows itself in many ways; but to point out its existence must suffice for the present paper.

At the present time the demand for the higher education of women is met in three different ways:

1. In separate colleges for women, with courses of study more or less parallel with those given in colleges for men. In some of these the

teachers are all women, in some mostly men, and in others a more or less equal division obtains. In nearly all these institutions, those old traditions of education and discipline are more prevalent than in colleges for men, and nearly all retain some trace of religious or denominational control. In all, the *Zeitgeist* is producing more or less commotion, and the changes in their evolution are running parallel with those in colleges for men.

2. In annexes for women to colleges for men. In these, part of the instruction to the men is repeated for the women, though in different classes or rooms, and there is more or less opportunity to use the same libraries and museums. In some other institutions, the relations are closer, the privileges of study being similar, the difference being mainly in the rules of conduct by which the young women are hedged in, the young men making their own.

It seems to me that the annex system cannot be a permanent one. The annex student does not get the best of the institution, and the best is none too good for her. Sooner or later she will demand it, or go where the best is to be had. The best students will cease to go to the annex. The institution must then admit women on equal terms, or not admit them at all. There is certainly no educational reason why a woman should prefer the annex of one institution when another equally good throws its doors wide open to her.

3. The third system is that of coeducation. In this system young men and young women are admitted to the same classes, subjected to the same requirements, and governed by the same rules. This system is now fully established in the State institutions of the North and West, and in most other colleges in the same region. Its effectiveness has long since passed beyond question among those familiar with its operation. Other things being equal, the young men are more earnest, better in manners and morals, and in all ways more civilized than under monastic conditions. The women do more work in a more natural way, with better perspective and with saner incentives than when isolated from the influence of society of men. There is less of silliness and folly where a man is not a novelty. In coeducational institutions of high standards, frivolous conduct or scandals of any form are rarely known. The responsibility for decorum is thrown from the school to the woman, and the woman rises to the responsibility. Many professors have entered western colleges with strong prejudices against coeducation. These prejudices have not often endured the test of experience with men who have made an honest effort to form just opinions.

It is not true that the character of the college work has been in any way lowered by coeducation. The reverse is decidedly the case. It is true that untimely zeal of one sort or another has filled the West with a host of so-called colleges. It is true that most of these are weak and

doing poor work in poor ways. It is true that most of these are coeducational. It is also true that the great majority of their students are not of college grade at all. In such schools low standards rule, both as to scholarship and as to manners. The student fresh from the country, with no preparatory training, will bring the manners of his home. These are not always good manners, as manners are judged. But none of these defects is derived from coeducation; nor are any of these conditions made worse by it.

Very lately it is urged against coeducation that its social demands cause too much strain both on young men and young women. College men and college women, being mutually attractive, there are developed too many receptions, dances and other functions in which they enjoy each other's company. But this is a matter easily regulated. Furthermore, at the most the average young woman in college spends in social matters less than one tenth the time she would spend at home. With the young man the whole matter represents the difference between high-class and low-class associates and associations. When college men stand in normal relation with college women, meeting them in society as well as in the class room, there is distinctly less of drunkenness, rowdyism and vice than obtains under other conditions. And no harm comes to the young woman through the good influence she exerts. To meet freely the best young men she will ever know, the wisest, cleanest and strongest, can surely do no harm to a young woman. Nor will the association with the brightest and sanest young women of the land work any harm to the young men. This we must always recognize. The best young men and the best young women, all things considered, are in our colleges. And this has been and will always be the case.

It is true that coeducation is often attempted under very adverse conditions. Conditions are adverse when the little girls of preparatory schools and schools of music are mingled with the college students and given the same freedom. This is wrong, whatever the kind of discipline offered, lax or strict; the two classes need a different sort of treatment.

When young women have no residence devoted to their use, and are forced to rent parlors and garrets in private houses of an unsympathetic village, evil results sometimes arise. Not very often to be sure, but still once in a while. These are not to be charged to coeducation but to the unfit conditions which make the pursuit of personal culture difficult or impossible. Women are more readily affected by surroundings than men are, and squalid, ill-regulated, Bohemian conditions should not be part of their higher education.

Another condition very common and very undesirable is that in which young women live at home and traverse a city twice each day

on railway or street cars to meet their recitations in some college. The greatest instrument of culture in a college is the 'college atmosphere,' the personal influence exerted by its professors and students. The college atmosphere develops feebly in the rush of a great city. The 'spur-studenten' or railway track students, as the Germans call them, the students who live far from the university, get very little of this atmosphere. The young woman who attends the university under these conditions contributes nothing to the university atmosphere, and therefore receives very little from it. She may attend her recitations and pass her examinations, but she is in all essential respects 'in absentia,' and so far as the best influences of the university are concerned, she is neither 'coeducated' nor 'educated.' The 'spur'-student system is bad enough for young men, virtually wasting half their time. With young women the condition of continuous railroading, attempted study on the trains, the necessary frowsiness of railway travel and the laxness of manners it cultivates, are all elements very undesirable in higher education. If young women enter the colleges, they should demand that suitable place be made for them. Failing to find this, they should look for it somewhere else. Associations which develop vulgarity cannot be used for the promotion of culture either for men or for women. That the influence of cultured women on the whole is opposed to vulgarity is a powerful argument for education, and is the secret basis of much of the agitation against it.

With all this it is necesary for us to recognize actual facts. There is no question that a reaction has set in against coeducation. The number of those who proclaim their unquestioning faith is relatively fewer than would have been the case ten years ago. This change in sentiment is not universal. It will be nowhere revolutionary. Young women will not be excluded from any institution where they are now welcomed, nor will the almost universal rule of coeducation in state institutions be in any way reversed. The reaction shows itself in a little less civility of boys towards their sisters and the sisters of other boys; in a little more hedging on the part of the professors; in a little less pointing with pride on the part of college executive officials. There is nothing tangible in all this. Its existence may be denied or referred to ignorance or prejudice.

But such as it is, we may for a moment inquire into its causes. First as to those least worthy. Here we may place the dislike of the idle boy to have his failures witnessed by women who can do better. I have heard of such feelings, but I have no evidence that they play much actual part in the question at issue. Inferior women do better work than inferior men because they are more docile and have much less to distract their minds. But there exists a strong feeling among rowdyish young men that the preference of women interferes with rowdyish

practices. This interference is resented by them, and this resentment shows itself in the use of the offensive term 'coed' and of more offensive words in vogue in more rowdyish places. I have not often heard the term 'coed' used by gentlemen, at least without quotation marks. Where it is prevalent, it is a sign that true coeducation—that is, education in terms of generous and welcome equality—does not exist. I have rarely found opposition to coeducation on the part of really serious students. The majority are strongly in favor of it but the minority in this as in many other cases makes the most noise. The rise of a student movement against coeducation almost always accompanies a general recrudesence of academic vulgarity.

A little more worthy of respect as well as a little more potent is the influence of the athletic spirit. In athletic matters, the young women give very little assistance. They cannot play on the teams, they can not yell, and they are rarely generous with their money in helping those who can. A college of a thousand students, half women, counts for no more athletically than one of five hundred, all men. It is vainly imagined that colleges are ranked by their athletic prowess, and that every woman admitted keeps out a man, and this man a potential punter or sprinter. There is not much truth in all of this, and if there were, it is of no consequence. College athletics is in its essence by-play, most worthy and valuable for many reasons, but nevertheless only an adjunct to the real work of the college, which is education. If a phase of education otherwise desirable interferes with athletics, so much the worse for athletics.

Of like grade is the feeling that men count for more than women, because they are more likely to be heard from in after life. Therefore, their education is of more importance, and the presence of women impedes it.

A certain adverse influence comes from the fact that the oldest and wealthiest of our institutions are for men alone or for women alone. These send out a body of alumni who know nothing of coeducation, and who judge it with the positiveness of ignorance. Most men filled with the time-honored traditions of Harvard and Yale, of which the most permeating is that of Harvard's and Yale's infallibility, are against coeducation on general principles. Similar influences in favor of the separate education of women go out from the sister institutions of the East. The methods of the experimenting, irreverent, idol-breaking West find no favor in their eyes.

The only serious new argument against coeducation is that derived from the fear of the adoption by universities of woman's standards of art and science rather than those of men, the fear that amateurism would take the place of specialization in our higher education. Women

take up higher education because they enjoy it; men because their careers depend upon it. Only men, broadly speaking, are capable of objective studies. Only men can learn to face fact without flinching, unswayed by feeling or preference. The reality with woman is the way in which the fact affects her. Original investigation, creative art, the 'resolute facing of the world as it is'—all belong to man's world, not at all to that of the average woman. That women in college do as good work as the men is beyond question. In the university they do not, for this difference exists, the rare exceptions only proving the rule, that women excel in technique, men in actual achievement. If instruction through investigation is the real work of the real university, then in the real university the work of the most gifted women may be only by play.

It has been feared that the admission of women to the university would vitiate the masculinity of its standards, that neatness of technique would replace boldness of conception, and delicacy of taste replace soundness of results.

It is claimed that the preponderance of high-school-educated women in ordinary society is showing some such effects in matters of current opinion. For example, it is claimed that the university extension course is no longer of university nature. It is a lyceum-course designed to please women who enjoy a little poetry, play and music, read the novels of the day, dabble in theosophy, Christian science, or physic psychology, who cultivate their astral bodies and think there is something in palmistry, and are edified by a candy coated ethics of self-realization. There is nothing ruggedly true, nothing masculine left in it. Current literature and history are affected by the same influences. Women pay clever actors to teach them—not Shakespeare or Goethe, but how one ought to feel on reading King Lear or Faust or Saul. If the women of society do not read a book it will scarcely pay to publish it. Science is popularized in the same fashion by ceasing to be science and becoming mere sentiment or pleasing information. This is shown by the number of books on how to study a bird, a flower, a tree, or a star, through an opera glass, and without knowing anything about it. Such studies may be good for the feelings or even for the moral nature, but they have no elements of that 'fanaticism for veracity,' which is the highest attribute of the educated man.

These results of the education of many women and a few men, by which the half-educated woman becomes a controlling social factor have been lately set in strong light by Dr. Münsterberg. But they are used by him, not as an argument against coeducation, but for the purpose of urging the better education of more men. They form likewise an argument for the better education of more women. The

remedy for feminine dilettantism is found in more severe training. Current literature as shown in profitable editions reflects the taste of the leisure class. The women with leisure who read and discuss vapid books are not representative of woman's higher education. Most of them have never been educated at all. In any event this gives no argument against coeducation. It is thorough training, not separate training, which is indicated as the need of the times. Where this training is taken is a secondary matter, though I believe, with the fullness of certainty that better results can be obtained, mental, moral and physical in coeducation, than in any monastic form of instruction.

A final question: Does not coeducation lead to marriage? Most certainly it does; and this fact can not be and need not be denied. The wonder is rather that there are not more of such marriages. It is a constant surprise that so many college men turn from their college associates and marry some earlier or later acquaintance of inferior ability, inferior training and often inferior personal charm. The marriages which result from college association are not often premature—college men and college women marry later than other men and women—and it is certainly true that no better marriages can be made than those founded on common interests and intellectual friendships.

A college man who has known college women, as a rule, is not drawn to those of lower ideals and inferior training. His choice is likely to be led toward the best he has known. A college woman is not led by mere propinquity to accept the attentions of inferior men.

Where college men have chosen friends in all cases both men and women are thoroughly satisfied with the outcome of coeducation. It is part of the legitimate function of higher education to prepare women, as well as men, for happy and successful lives.

An Eastern professor, lately visiting a Western State university, asked one of the seniors what he thought of the question of coeducation.

'I beg your pardon,' said the student, 'what question do you mean?'

'Why coeducation,' said the professor, 'the education of women in colleges for men.'

'Oh,' said the student, 'coeducation is not a question here.'

And he was right. Coeducation is never a question where it has been fairly tried.

THE SIGNIFICANCE OF THE CONDITION OF YOUNG BIRDS AT BIRTH.

By W. P. PYCRAFT, A.L.S., F.Z.S.

IT is a matter of common knowledge that the young of birds are ushered into the world in very different degrees of development, according to the species to which they belong. The helplessness of the callow young of the crow-tribe, for example, stands in strong contrast to the activity displayed by the young of the game-birds. Again the young of birds are remarkable for the very wide degrees of variation which obtain in the matter of clothing on their escape from the shell, variations which range from absolute nakedness to abundant feathering, albeit feathering of a peculiar type.

Out of these commonplace facts the systematic ornithologists, on the one hand, and the philosophical zoologists, on the other, have woven theories which have undergone many changes; but, so far, we venture to think, all have missed the point. A survey of the work of the systematic ornithologist will show that on more than one occasion the condition of the young at birth has been made either the corner-stone of a classification, or one of the main supports thereof.

For the one purpose or the other these young have been duly labeled and classified. In consequence, they may be contemplated from two different points of view: (1) According to their helplessness or otherwise, and (2) according as they are clothed or otherwise. When the young emerge from the shell in a fully active state, they are known as nidifugous or præcocial; those, on the contrary, which are quite blind and helpless on leaving the shell are known as nidicolous or altricial young. The nidicolous young may be, as we have already remarked, absolutely naked, in which case they are said to be psilopædic. If, on the other hand, they are clothed, they are said to be ptilopædic. All nidifugous young are ptilopædic. The nidicolous young, being helpless and often blind, are assiduously fed by the parents, whilst among the nidifugous types, the young either feed themselves under the guidance of their parents, or accompany them in the search for food, and are fed by the way as the food is procured.

Two very different standards of thought have inspired those who selected the condition of the young at birth as a basis of avian classification. The older naturalists, adopting what we now regard as the purely artificial standards of their time, grouped birds according as

the young were 'altricial' or 'præcocial,' nidicolous or nidifugous, thus creating an entirely arbitrary system of the same value as those other systems based upon the form of the bill, shape of the wing and so on. The post-Darwinians, working on the lines of evolution, see in these very different conditions, a phylogenetic significance, and regard the nidifugous as more reptilian than the nidicolous young. Consequently, those groups which have nidifugous young are to be regarded as standing comparatively low in the scale, whilst those with nidicolous young must be considered to have risen to a higher plane. This newer view is undoubtedly an improvement on the older, but it must, we think, give place to a yet wider interpretation.

If we turn from the purely systematic point of view to the more philosophical side of the question, as it at present stands, we shall, I think, find an equally unsatisfactory state of affairs. The two most recent text-books of zoology may be cited as authorities.

According to Jordan and Kellogg ('Animal Life,' 1901), 'those animals are highest in development, with best means of holding their own in the struggle for life, that take best care of their young,' and 'among the lower or more coarsely organized birds, such as the chicken, the duck, and the auk, as with reptiles, the young animal is hatched with well-developed muscular system and sense organs, and is capable of feeding itself,' but the offspring of the 'more highly organized forms, such as the thrushes, doves, and song-birds generally' are hatched in a wholly helpless condition, with ineffective muscles, deficient senses, and dependent wholly upon the parent. Similarly Shipley and MacBride write: "The manner the young are cared for is a most important feature. . . . The just-hatched young of the Pheasant and Game-birds are able to run about and look after themselves, whereas those of the Passeres or Songsters, require constant care and attention for a long time. These last are considered . . . to be the most highly developed of all birds, both as to their intellects and their flying powers, so that it is hardly too much to say that the increasing sacrifice of the parents on behalf of the young has had its reward, in the improvement it has brought about in all the faculties of the race."

Those who are responsible for the views just enunciated appear to have forgotten that the cormorants, for example, also bring their young into the world blind, naked and helpless, and not infrequently rear them in a nest of sticks on tree tops; yet the warmest admirer of these birds can not claim for them either a high degree of organization or great intelligence among birds. Their near allies, the darters, gannets, tropic and frigate birds also have helpless young, which in the case of the frigate birds and darters are also reared in nests in trees. We might multiply instances, but these are sufficient for our

present purpose. They show at least that 'sacrifice of the parents on behalf of the young' has not been uniformly rewarded 'in the improvement . . . in all the faculties of the race.' More than this, they seem to me to show that this factor has had little or nothing to do with either inclination or structural development.

The real explanation of the matter seems rather to turn upon a question of expediency, designed, so to speak, to reduce infant mortality.

We shall show presently, on evidence well nigh incontrovertible, that the nidifugous condition is indeed a primitive one, but associated with a *strictly arboreal* habitat. This is an important point, as the nidifugous condition is commonly regarded as peculiar to, and possible only in, a terrestrial habitat. Let us assume for the moment that the former is an established fact.

One great disadvantage attendant on precocious development of the young whose nursery is the tree top is obvious—the nestlings would be constantly in danger of falling to the ground, and a large number would indeed meet this fate. Some would fall through weakness, the habit of dispersing themselves among the branches of trees in which the nest was placed resulting in a loss of regular food supply, owing to the difficulty of being on the spot when the parents returned with food. Thus the more sedentary members of the family would stand the best chance of being regularly fed, but among these the danger of falling by accident would be an ever present one. Once on the ground it is probable they would perish speedily, for it is almost certain that the *earliest* birds were entirely arboreal, and either would not or could not seek for lost offspring amid the thick undergrowth.

Now two courses were open whereby this infant mortality could be reduced. Either the eggs could be deposited on the ground, or the activity of the young curtailed. The game-birds, ducks and geese, rails, cranes and plovers may serve for examples of those species which have descended from the trees to the ground for nesting purposes, and although, as a consequence, the young have undergone considerable modifications in adaptation to the new environment, these changes are not so striking as those which have taken place among the young of the tree-dwelling species to be described presently.

The modifications which we should expect to find in the offspring of those species which, instead of curtailing the activity of the young, descended to the ground to breed, would be (1) peculiar habits of concealment aided by protective coloration; and (2) a reduction in the size of the wings and feet, now no longer required solely as grasping organs.

Protective coloration and peculiar habits of concealment are obviously direct responses to the increased need of escaping enemies, and hence we find these devices have been universally adopted. It is

possible, however, that protective coloration was preceded by the development of precocious powers of flight, which have since been discarded by all save the game-birds. Probably this rejection was brought about because excessive activity on the ground was found to be as fatal as in the trees; since the young, in escaping from one danger, would be liable to run into another, or to stray too far away to render return possible.

At the present day, though the young of all the game-birds are protectively colored they have yet preserved more or less perfectly their earlier precocial powers of flight, the birds, when escaping danger, using their wings either like the ostrich, as an aid in running, or in actual flight, and there is evidence to show that the broods in consequence suffer. As an example, the observations of Mr. Ogilvie Grant on this subject may be cited. In writing of the common pheasant, he tells us that the mother, on alarm, with a warning note to the young, at once flies off and leaves them to take care of themselves. This they do by scattering in all directions, and then squatting down and trusting to their protective coloration for safety. Quiet restored, the parent returns, often only to recover but three or four of her chicks, the rest having strayed to such a distance that they are left to perish.

Thus, then, the hypothesis of precocious flight seems by no means an improbable one. Its development will be easy to understand when it is remembered that the raw material therefor is furnished by that aberrant member of the game-birds—the hoatzin. The life-history of this bird will be discussed later.

We may pass now to a consideration of those species which, retaining their arboreal nesting habits, have adopted the method of curtailing the activity of the young. This process was accomplished by reducing the food-yolk within the egg, and thus inducing an earlier hatching period. We may approximately measure the extent to which this reduction has been carried by the degree of helplessness displayed by the newly hatched bird, and by the nature and extent of its clothing.

The number of species which have adopted this expedient outnumber those which have not, and this speaks volumes for its success. As examples, we may instance the passerine or song-birds, parrots, cuckoos, birds of prey, cormorants and their allies, and the stork-tribe. The young of these are all born extremely helpless, many perfectly naked, others enveloped in a thick coat of down, whilst in some down is developed soon after hatching, and, in a few, not at all.

Having once however reduced the amount of food-yolk, return to the older fashion of nidifugous young became impossible, and this explains why nidicolous young are still born to those parents which have adopted the practice of depositing their eggs upon the ground. It proves that the arboreal habit has been forsaken since the specializa-

tion. Some, like the cormorants, herons and certain of the gull-tribe, for example, build as occasion demands, either on the ground or in trees. Now it is interesting to note that among these birds the young cormorants and herons are completely nidicolous, the young gulls only partially so, whilst the near and less specialized allies of the gulls, the plovers, have nidifugous young. This indicates that in the gulls the food-yolk is in process of reduction. To species breeding in large colonies, or on ledges of precipitous cliffs, the reduction of the food-yolk and helplessness of the young are obviously advantageous.

That this is so may be seen in the case of the colony-breeding species, since it would be impossible for the parents to recognize their own offspring, if nidifugous, when running about amid those of their neighbors. In consequence a large number would almost certainly go unfed and soon starve, whilst great activity among the young of the cliff-breeding species would be accompanied by an enormous mortality, owing to falls from the cliff.

It is contended that the facts so far submitted amply justify the interpretation put upon them, but the following instances should carry conviction. In the aberrant South American game-bird, the hoatzin, we have probably a direct survival of the protoavian type of nestlings. They are, of course, nidifugous, but they differ from all other nidifugous young in the prehensile character of their wings, which are armed with large claws borne upon the thumb and index digit. Claws on the wing are common among birds, and hitherto they have been regarded merely as vestiges—indices of a reptilian ancestry. The part which they play, however, in the life-history of the hoatzin, coupled with certain correlated modifications to be discussed presently, shows that they have a wider significance than this.

The adult hoatzin is an absolutely arboreal bird, inhabiting the dense scrub and trees bordering the lagoons and river banks of British Guiana and the Amazon Valley. Its powers of flight are extremely limited, and it has never been observed to alight upon the ground.

The young, like those of other nidifugous birds, are clothed in down, conspicuous, in the present instance, for its hair-like appearance and sparse distribution. But whilst the locomotion of the nidifugous young of other birds is bipedal that of the hoatzin must be described as quadrupedal, the wings as well as the legs being brought into requisition as the birds make their way along the branches. Even the beak is sometimes used, as in the parrots.

In a wing used as a prehensile organ we should expect to find certain peculiarities which would not be observable in the normal wing. These are not wanting. One of the first points which attract attention in the examination of such a wing is the great length of the hand, which

is considerably longer than the forearm. The thumb is found to be unusually long, and to extend beyond the level of the tip of the third digit. Both thumb and finger are armed with large claws. The index finger is furthermore remarkable in that it is produced beyond the fold of skin which runs along the hinder or post-axial border of the wing for the support of the quill-feathers. Examined further, the palmar surface of the thumb and second finger are found to be swollen into little cushions resembling the cushion-like undersurface of the finger-tips of the human hand. Next the budding quill-feathers attract attention, and if a series of young is being examined, probably the first point to be noted is the fact that the development of the quill feathers of the hand were peculiar inasmuch as in the older forms whilst the inner quills are found to have pushed their way some considerable distance beyond the post-axial border of the wing, the outer quills are only represented by simple down-feathers. Thus, a long, free finger-tip is left beyond the quills. The thumb also, as yet, bears only down-feathers, the future quills being conspicuous by their absence. On a little reflection the meaning of this becomes clear.

The arrested development of the quills of the thumb and the tip of the finger is an adaptation to the bird's peculiar needs, albeit a deep-seated character, dating from the dawn of avian development. If all the quills were to grow at an equal rate, a stage would soon arrive when the wing would be useless as a climbing organ, by reason of the developing feathers and so expose the bird to constant danger of falling before the quills had sufficiently developed to break the force of such a fall. Thus then the arrested development of the quills begins to look as if it might have a definite meaning, and this becomes a certainty when still older specimens are examined. In them we find that as soon as the inner quills of the second digit have grown sufficiently long to enable the bird to recover itself in falling the hand begins to shorten, and the claw to diminish, till at the time of puberty the hand has become *shorter* than the forearm, the claws both of the thumb and finger have disappeared, the thumb no longer extends to the level of the third digit, and the second finger no longer projects beyond the hinder wing fold (post patagium).

That the structural peculiarities observable in the wing of the hoatzin are not recently acquired characters can not be doubted. The presence of the claws is almost sufficient to prove this, for having once become vestigial it is unlikely they would reacquire their primitive size.

But we have other evidence affording the strongest confirmation of the contention that the wing of the hoatzin represents an ancient order of things once common to all birds. This evidence is 'writ large' upon the wing of those allies of the hoatzin, the common fowl, the

turkey or the pheasants, for example. Herein we find the same developmental stages, but with certain modifications easy to interpret.

In the limb itself—as considered apart from the appendages, the incipient quills or flight-feathers—one of the first things to attract attention is the hand, which although relatively shorter than that of the hoatzin, is still longer than the forearm; next the cushion-like pads of the thumb and second finger are missed, as also are the claws. That of the thumb, however, is generally present though in an extremely reduced condition, and in the index finger it appears only during embryonic life.

The flight feathers again reveal some very interesting features, inasmuch as the inner quills develop at a rate relatively much greater than in the hoatzin, so that they become functional earlier in the life-history, whilst the outer quills, three in number, are still only represented by delicate down feathers, thus, be it noted, leaving a free finger-tip as in the hoatzin. The abrupt changes from quill feathers to nestling down observable in the wing of the chick and turkey seem to show that the quills have undergone a process of forcing or accelerated development, in which the inner quills have developed at an excessively rapid rate, so as to out-distance their fellows at the distal or outer extremity of the wing, which as yet are only represented by nestling down. The rapid development of the inner quills is probably due to the fact that the terrestrial mode of life demanded the aid of the wings for the purposes of flight at an earlier period than would be the case if they dwelt, like the hoatzin, in comparative security among the trees.

The developmental history of the wings of the fowl and its allies seems to leave but little room for doubt that the ancestors of these birds, like the hoatzin, were hatched in trees and crawled about among the branches. Moreover, the change from an arboreal to a terrestrial nursery seems to have taken place comparatively recently. On no other assumption can we explain the free finger-tip and the arrested development of the outer quill feathers. Nevertheless, a sufficient time has elapsed wherein to bring about the suppression of the claws. That of the index digit, being no longer useful, appearing later and later in development, has now entirely ceased to put in an appearance save only during embryonic life; in other forms, separated by a still greater lapse of time from their tree-crawling ancestors, even the embryonic claw has ceased to be.

Of considerable importance is the fact that whilst in the hoatzin and the fowl and its allies the quill feathers appear long before the contour feathers of the body—that is to say, whilst the body is still clothed in down—in the nidifugous young of ground-breeding forms such as the plovers, for example, which seek protection by concealment alone, unaided by flight, the quill feathers appear together with the

contour-feathers of the body and at a much later date than in the above. So also with the nidifugous young of aquatic forms.

The accelerated development of the quills is probably a remnant of an earlier phase in the life-history before protective coloration was adopted. As we have already shown, precocious flight is attended by too many perils to prove an effective means of escape from enemies.

In conclusion we may say a word about the young of the megapodes. The eggs of the megapode are, as is well known, hatched in decaying vegetables heaps, or in hot sand, instead of being incubated by the parents. To this end the amount of food-yolk within the egg has been enormously increased, enabling the normal nestling period to be passed within the egg, the young passing through the downy stage during embryonic life, and emerging from the shell, fully fledged.

That the ancestral megapode was originally hatched in trees like the young hoatzin, there can be no doubt, since like the latter the wing of the young shows a free finger-tip and an arrested development of the outer quill feathers, characters which, as we have already seen, are direct adaptations to the peculiar locomotion of tree-climbing nestlings. We may be almost certain that the increase in the food-yolk, just referred to, did not take place until some time after the descent to the ground for breeding purposes, since the wing of the young megapode forms an exact counterpart of that of the young fowl and turkey, and their allies, whilst, had the increase taken place earlier, the wing would have resembled that of the hoatzin in the possession of large claws. The latter are present now only during embryonic life.

The increase in the food-yolk, allowing the earlier nestling stages to be passed within the shell, must be accounted for by supposing the adult megapode to have been obliged to adopt this expedient to avoid perils attendant on normal incubation, perils which may since have passed away leaving no record of their nature. A return to the normal method of incubation is now impossible, the instinct therefor having been replaced by that which induces the birds to bury their eggs and leave them to be hatched by heat other than that of their bodies.

Finally, we may compare the hoatzin with the ancient archæopteryx, and the result of such a comparison will go far to prove that the former represents the most primitive of living birds.

That archæopteryx was strictly arboreal there can be no doubt—the structure of the feet indicates this much; and its long tail is a scarcely less certain index, for such an appendage is undoubtedly but ill-adapted for ground-dwelling habits. The long hand, and the large claws thereon are, so to speak, primitive characters. The period of their greatest functional activity was during the nestling stage when the young clambered about among the branches of the trees like the young hoatzin of to-day. The species was perhaps not phylogenetically

old enough to eliminate the traces of nestling-life on reaching puberty, when the quills rendered claws, and climbing, not only needless, but impossible; hence then the retention by the adult of both elongated manus, free finger-tips and claws. It has been suggested, however, that the claws and elongated manus of the adult archæopteryx were periodically functional, the periods being the moulting seasons. It is well known that many existing birds, the anseres to wit, when moulting, shed all the quills at once, and in consequence are for a season flightless. It may well be that this system of losing the quill is a primitive one and obtained in archæopteryx, in which case it is obvious that in a bird so strictly arboreal, the climbing hand of infancy would be of some service. The more usual method of moulting the quills in couples prevailing amongst modern birds so as not to impair the power of flight has probably come about by selection, and hence the reduced and clawless hand of the adult hoatzin, fowl and turkey for example; birds in which, for reasons already explained, the primitive form of manus is still temporarily exhibited by the nestling.

Thus then, through the wing of the hoatzin we have a revelation of a phase of bird-life hitherto unsuspected; inasmuch as its peculiar developmental stages, each with its period of functional activity, enable us to interpret the hitherto meaningless and puzzling characters seen in the wing of the fowl and turkey, and their allies. These constitute wellnigh invincible proofs of an earlier and universal arboreal existence, extending back to the time of the earliest known bird archæopteryx. Certainly the skeleton, especially the wing, lends the strongest support to this view. This carries us further back still, and suggests the conclusion that the reptile stock from which the aves are descended was probably also arboreal.

That too much stress has been laid by systematists on the condition of the young birds at birth is admitted. It is further maintained here that its significance has been misunderstood, and that the facts now brought forward are strong enough, on the one hand, to refute the older views, and on the other, to justify the theory, firstly, that birds were originally arboreal and their young nidifugous; secondly, that nidicolous habits and helplessness of young birds are specialized adaptations to an arboreal or gregarious mode of life; and, thirdly, that the young of gallinaceous birds form a link in the chain of the evolution of nidifugous habits. The free finger-tip and arrested development of the outer quill-feathers point to a prior arboreal habit; whilst the accelerated development of the inner quill-feathers indicates an adaptation to enable the young to escape from the enemies surrounding a terrestrial nursery. The third and last stage is represented by the protective coloration, a device which has been almost universally adopted by nidifugous birds, owing to its greater effectiveness.

THE MOTIVE POWER OF HEAT.

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MR. ALFRED RUSSEL WALLACE, in his 'Wonderful Century,' describes those great material and intellectual achievements which especially distinguish the nineteenth century from any and all of its predecessors, and shows how fundamental is the change they have effected in our life and civilization. From a comparative estimate of the number and importance of these achievements, he concludes that not only was the century just passed superior to any one that had gone before, but that it must in its results be compared with the whole preceding historical period. It, therefore, marks the beginning of a new era of human progress.

There appears, however, upon looking back through the long, dark vista of human history, one step in material progress that seems to be really comparable with several steps of modern times. It was when fire was first utilized and became the servant and friend rather than the master and enemy of man. From that day to this, fire, in various forms and in ever-widening spheres of action, has been the greatest, the essential factor in that increase of man's power over nature, which has in turn been a chief means of developing what we term civilization. As Mr. Fernald, in his 'Gulf of Fire,'* points out, all men, however widely separated by millenniums of time and by utmost range of space, by mountains, deserts and oceans, by color, language and occupation, by custom and religion, all agree in this—they make fire a servant and a friend. Mr. Fernald shows how the firebrand draws an impassable line between man and the brute creation, and graphically depicts the part played by the ancient element fire in aiding man along that upward path which, having entered, he had only to follow on to make the universe his own.

Steam engines in their infancy were known as 'fire' (*i. e.*, heat) engines; and, in point of fact, the older term is the more correct, because the water or steam is used only as a convenient medium through which the form of energy which we call heat is made to perform the required mechanical operations. The claims of the steam engine (as locomotive, marine and stationary) to the greatest share in the marvelous material progress of the nineteenth century are too

* *Harper's Monthly Magazine*, July, 1902.

well known and acknowledged to need recounting here. We wish merely to call to mind one upon whose theoretical deductions all the advances in the science of thermodynamics since his day have been based: Sadi Carnot, a young French military engineer.

Appreciation of genius is a mark of the civilization and culture of a people, and the world can ill afford to neglect the memory not only of the men who by practical application have helped to make that civilization possible, but also of those who by theoretical deduction have pointed out the way of progress. The world must needs remember those by whose brain power, as Mr. Fernald says, we have been

NICHOLAS LEONARD SADI CARNOT (1796–1832), FATHER OF THE SCIENCE OF THERMODYNAMICS.

enabled to cross the gulf of fire to the paradise of invention and achievement that lies beyond, of which none can see the farther bound. Every schoolboy knows of James Watt, of the Stephensons and their 'Rocket,' but who, save the special student, has ever heard of Sadi Carnot?

Watt made his great improvements in the steam engine (really almost invented it) during the last quarter of the eighteenth century. But for the next fifty years, including those covered by the life of Carnot, the development was seemingly the result of chance. The

recognition of this fact led Carnot, when but twenty-eight years old, to undertake to lay the foundation on which all future progress was to rest, by publishing in 1824 a small memoir, 'Reflexions sur la puissance motrice du feu' ('Reflections on the Motive Power of Heat'). George Stephenson made his wonderfully simple, but exceedingly effective, improvements in the locomotive from 1814 to 1829, at a time when the world was still ignorant of the value of Carnot's ideas. To-day, however, when physicists fully realize the importance of his work, the world at large is still ignorant of Carnot's biography; and so it is the purpose of this article to recall the life and character of him whose name must always be intimately associated with the development of the modern 'heat engine' and its influence upon civilization.

Carnot's father, Lazare Nicholas Marguerite Carnot, soldier and statesman, was a member of one of the oldest and most distinguished families in France. Educated as a military engineer, he gained a second lieutenancy at eighteen and in later life won renown as a mathematical writer. Minister of War under Napoleon, he took a prominent part in the French Revolution and was regarded by his countrymen as the genius and organizer of victory, exhibiting the talents later illustrated by the German, Von Moltke. He voted against the extension of the consulate and against the Empire, and was forced into private life in the early days of the latter and died, proscribed, at Magdeburg in 1823. Carnot's brother, Lazare Hippolyte Carnot, was twice a member of the Chamber of Deputies and also Minister of Public Instruction. He died as recently as 1888. A fact which brings Carnot's life still closer to us of to-day is that the late president of France, Sadi Carnot, who was assassinated in 1890, was a grand-nephew of the founder of thermodynamics, the subject of this sketch.

Nicholas-Leonard-Sadi Carnot was born June 1, 1796, in the smaller Luxembourg palace, a part of which was occupied by his father as a member of the Directory. Christened 'Sadi' after the celebrated Persian poet and moralist, he merited the name in that his nature proved to be highly artistic as well as philosophic. Hardly a year after Carnot's birth, in consequence of his father's proscription and enforced exile, his mother took refuge at her homestead in Saint Omer. The boy's delicate constitution was so affected by the vicissitudes of his mother's life that he regained his bodily powers later on only by judicious exercise. He was of medium stature, gifted with extreme sensibility and at the same time with extreme energy, generally reserved, sometimes timid, but singularly quick upon occasion. Whenever he believed that he was encountering injustice, nothing served to restrain him. An incident, which his brother has described, exhibits him in this light even as a child.

The Directory giving place to the Consulate, Carnot senior, after two years of exile, reentered France, being called to the Ministry of War by Bonaparte, who, remembering Carnot's services to him at the beginning of his career, wished to continue the intimate relations that had existed between them during the Directory. Often when the minister came to work with the consul he brought his son, now about four years of age, and left him in the charge of Madame Bonaparte, who was very fond of him. On one such occasion, Madame Bonaparte and some of her ladies, mounted on a little raft, were paddling about upon a pond in the palace court. Napoleon, happening along, began to amuse himself by throwing stones at the raft so as to splash the water over the clean dresses of the would-be sailors. The latter feared to manifest their displeasure, but the little boy, after watching the procedure for a while, suddenly faced the conqueror of Marengo and, shaking a stick at him, cried: 'Animal of a First Consul, are you not ashamed to torment these ladies!'

LAZARE NICHOLAS MARGUERITE CARNOT, FATHER OF NICHOLAS LEONARD SADI CARNOT.

Sadi showed such interest in machinery and applications of physics that his father early directed his studies toward science, and he was just sixteen when he entered the Ecole Polytechnique in 1812. He made rapid progress, graduating the next year with first rank in the artillery. But he was thought too young for the military school at Metz, and was allowed to continue his studies at Paris for another year. Having fought with his gallant fellow-students at Vincennes in March, 1814, he returned when peace was established to his studies at the Polytechnique, but left in October with the rank of sixth-cadet of engineers and repaired to Metz as a sublieutenant in the school of practical fortifications.

The events of 1815 brought Carnot senior again upon the political field during the 'Hundred Days.' This was the occasion for Sadi to make a test of men, of which he never spoke afterwards without disgust. His little quarters of sublieutenant were visited by certain superior officers, who did not hesitate to mount three flights of stairs in order to greet the son of the new minister. Waterloo put an end to

all this. The Bourbons reestablished upon the throne, General Carnot was proscribed, and Sadi was sent successively to several forts as engineer, to count bricks, to repair walls and to draw up plans destined to lie buried in the official archives. However, he worked conscientiously, although his name, which but now had won for him so many official pleasantries, served to retard his due advancement for some time. In 1819, desiring greater leisure for private study, Carnot presented himself as a candidate for a new staff-corps then forming, and received an appointment as lieutenant on the general staff. His duties brought him to Paris and the surrounding country, and he led a studious life, interrupted but once by several happy months spent with his brother and exiled father at Magdeburg.

He followed original lines in all his work, and was a constant enemy to the traditional and conventional. Upon his table were found only Pascal, Molière or La Fontaine, and he knew these favorites by heart. With him music was a passion inherited from his mother; not content in attaining a superb execution on the violin, he must needs plunge into the study of theory. His insatiable intelligence led him to follow assiduously courses at the Collège de France, at the Sorbonne and at the École des Mines. He visited manufacturing plants and familiarized himself with the different processes. Mathematical sciences, natural history, industrial arts, political economy, all these were cultivated with ardor. Not only did he indulge in gymnastic exercises, but he investigated the theory of fencing, swimming, dancing and skating.

Toward the end of 1826 he requested and obtained his return to the corps of engineers, receiving by reason of seniority the rank of captain. However, military service was onerous to him, jealous as he was of his liberty, and in 1828 he resigned in order to devote himself more fully to science.

His manuscript notes show that he had perceived the relation which is believed to exist between heat and mechanical work; and after having established the principle which now bears his name, he began researches which would have established with surety the principle of equivalence of mechanical energy and heat had they not been suddenly interrupted by his enthusiastic participation in the revolution of 1830.

An anecdote which shows his impetuous nature as a man, even as we have seen it exhibited as a child, is also given us by his brother. On the day of the funeral of General Lamarque, Carnot was strolling for curiosity's sake in the neighborhood of the insurrection. A cavalier who headed a charge and who appeared intoxicated passed down the street at a gallop, flourishing his saber and striking the pedestrians. Carnot rushed forward nimbly avoiding the soldier's sword, seized him

by the leg, threw him to the earth, tumbled him into the gutter and went on his way amid the shouts of the crowd, who were amazed at this exhibition of dexterity and strength.

The hopes of the Democracy, however, appeared to be short-lived, and Carnot returning to his scientific studies applied to them his pent-up political ardor. He undertook important researches upon the physical properties of gases and vapors, especially upon their elastic tensions. Unfortunately his tables were not completed. His excessive application was followed by an attack of scarlet fever in June, 1832, and while convalescing from this attack he was seized on the twenty-fourth of August with the epidemic of cholera and died in a few hours. As if by a sinister presentiment he had been watching the advance of the epidemic very closely, when without previous warning he was carried away upon its tide in the very prime of life, being but thirty-six years of age.

Although the one work that he published is sufficient to keep his name from being forgotten among scientists, yet it is from portions of his note-book that we learn of the activity of his spirit, the variety of his knowledge, his love for humanity and his clear ideas of justice and liberty. In these notes we find rules of practical conduct; observations later embodied in his memoir; some thought that happened especially to strike him, sad or gay; sometimes also, though seldom, an outburst of ill feeling against men and society; thoughts on general political economy or on taxation in particular; and on morals and religion. Some of the ideas contained in these notes remind one not a little of 'Poor Richard's Almanac,' and are so quaintly set that it will doubtless be of interest to quote a few.

The promptness with which a resolution comes to one generally accords with the justice of it.

Never feign a character that you do not possess, and never assume a personality that you will not be able to sustain.

Speak little of that which you know; not at all of that which you do not know. Why not the more often say: 'I do not know'?

Hope is the greatest of blessings; it is necessary, therefore, in order to be happy, to sacrifice the present to the future.

I do not know why one always confounds the two expressions: 'Good sense' and 'common sense.' Nothing is less common than good sense.

People speak of the laws of war, as if war were not the destruction of all law.

Men attribute to chance that of which they do not know the cause. If they come to divine the cause, the chance disappears. To say that a thing happens by chance is to say that we have not been able to foresee it. What is chance for an ignorant man, may not be chance for a man more instructed.

Carnot possessed a repugnance toward publicity, so that, except in conversation with a small number of intimate friends, those among

whom he lived were entirely ignorant of the fund of knowledge he had accumulated. His brother, who was called upon to read the manuscript of his memoir on the motive power of heat in order to see that it was clear enough to be understood by others than scientists, says that he never did understand why Carnot made this one exception. It seems that his solitary life in small garrisons, in the office and in the laboratory served to increase his natural reserve. Yet he was not in the least reticent in a small company; he took part willingly in the gayest joys and abandoned himself to the liveliest conversation. His language was then full of witticism, biting but not malignant, original but not eccentric, sometimes paradoxical, but never with any other pretension than that of an active mind.

It was in 1824 while still an officer on the general staff that Carnot published his 'Reflections on the Motive Power of Heat.' Struck with the fact that chance alone seemed to direct the construction of steam engines, he undertook to raise to the rank of a science the art that was still so imperfect in spite of its importance. He investigated the phenomena of the production of motion by heat from the most general point of view, independent of any particular mechanism and of any particular agent. It was only some years after his death that the value of his work was revealed to his fellow countrymen by an echo from England. However, it did merit the attention of a few French scientists, notably the celebrated engineer, Clapeyron, who in 1834 published in the *Journal École Polytechnique* a paper which was a comment upon and an extension of the ideas of Carnot, in which he called attention to Carnot's reasoning, represented Carnot's processes in an analytical form and arrived at some new results, usefully applying, and for the first time, the principle of Watt's indicator diagram to the geometrical exhibition of the different quantities involved in the cycle of operations by which work is derived from heat by the temporary changes it produces in the volume and molecular state of bodies. It was through this work of Clapeyron that Carnot's ideas became known to Lord Kelvin, who presented them to the world in 1848, pointing out that they enabled us to give for the first time an *absolute* definition of temperature, *i. e.*, a thermodynamic scale of temperature which is independent of the properties of any particular substance. On this scale the absolute values of two temperatures are defined to be in the same ratio as the amounts of heat-energy taken in and rejected by a perfect (*i. e.*, reversible) thermodynamic engine, working with its source and its refrigerator at the higher and lower of these temperatures respectively. Lord Kelvin showed that the ratio between these quantities of heat-energy depends only on these two working temperatures and is independent of the substance used in the engine,

and so the scale of temperature thus defined may be termed absolute. Moreover, such a scale leads at once to the idea of an absolute zero, for no engine could be supposed to convert more heat-energy into work than it received; and, choosing the temperature of the refrigerator (calling it T), so that no heat-energy is rejected by the engine, but all the heat-energy taken from the source is turned into work, it is impossible for T to be negative, else the engine would have an efficiency greater than 100 per cent. Therefore zero is the smallest algebraic value the temperature of the refrigerator can have, and temperatures reckoned from this zero are called absolute. The size of the degrees on this scale is arbitrary, and has been conveniently chosen so that there are one hundred degrees between the temperatures of boiling and freezing water. If now a reversible engine be worked between these temperatures and the quantities of heat-energy received and rejected be measured, the temperature of boiling water on the absolute scale may be found. It is not necessary actually to try the experiment, for the work done by the expansion of a substance which obeys the ordinary laws of gases may be calculated by the methods of the infinitesimal calculus. In this way Kelvin's thermodynamic scale has been shown to be practically identical with that of a perfect gas thermometer, which shows the absolute zero of the thermodynamic scale to lie about 273 degrees below the zero of the Centigrade scale.

Professor Tait has said: "Without this work of Carnot, the modern theory of energy, and especially that branch of it which is at present by far the most important in practice, the dynamical theory of heat, could never have attained in so few years its now enormous development. Carnot's claims to recognition are of an exceedingly high order, because they depend not merely upon his method, which is one of startling novelty and originality and is not confined to the subject of heat; but upon the fundamental principle upon which he based his mode of comparing the heat employed with the work procured from it. Every reasoner who has applied himself to the subject of heat since Carnot has gone right so far as he attended to Carnot's principle; but has inevitably gone wrong when he forgot or did not attend to it."

The two things which Carnot introduced, which were entirely original with him and which left his hands in an almost perfect form, were the idea of a 'Cycle of Operations' and the further idea of a 'Reversible Cycle,' giving also the notion of a 'Reversible and Perfect Engine,' showing that the efficiency of such depends only on temperature.

The peculiar merit of Carnot's reasoning consists in the idea of bringing the body back to its initial state as to temperature, density and molecular condition, after a cycle of operations, before making any assertion as to the amount of heat-energy gained or lost. This he

accomplished by causing the working substance (a gas in Carnot's case) to pass through two isothermal changes, the first at a higher and the second at a lower temperature, alternated with two adiabatic* changes by which the temperature of the working substance is allowed to fall and then raised again. Each separate step was itself reversible and so the whole cycle was reversible. The great virtue in this is that at the close of the cycle of operations the intrinsic energy of the body is exactly the same that it was at the beginning; and so we make no mistake in saying that the difference between the quantity of heat-energy given out by the body during the isothermal change at the higher temperature and that absorbed by it during the isothermal change at the lower temperature is exactly equal to the amount of external work done by the body in the course of the cycle.

By applying this principle Carnot showed that the production of motive power is possible wherever there is a difference of temperature, the motive power being due to a transfer of heat-energy from the hotter to the colder body, its quantity being independent of the agents employed to develop it, but depending solely upon the temperatures of the bodies between which the transfer occurs, provided the process is reversible.

The most striking fact concerning this memoir is that Carnot used hardly any mathematics at all, but arrived at his conclusions by sheer logical exercise of his mind, expressing the different processes entirely in words and using only such terms as would be clear to one not a scientist. Some of his conclusions are incorrect on account of the erroneous assumption of the materiality of heat, but sometimes he is led to conclusions correct in form, although the deduction is erroneous. Instinct seems to have led him in the right direction.

It may be of interest to go through Carnot's memoir and pick out the various important statements as he himself italicized them. They are in part as follows:

The production of motive power in the steam-engine is not due to a real consumption of the caloric, but to its transfer from a hotter to a colder body.

Wherever there is a difference in temperature the production of motive power is possible, and conversely.

The maximum motive power resulting from the use of steam is also the maximum motive power which can be obtained by any other means.

The motive power of heat is independent of the agents employed to develop it; its quantity is determined solely by the temperature of the bodies between

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*** By isothermal changes are meant changes in volume and pressure involving changes in the heat-energy of the working substance, but unaccompanied by any changes in temperature.**

By adiabatic changes are meant changes in volume and pressure involving changes in temperature, but unaccompanied by any gain or loss of heat-energy of the working substance.

which in the final result (*i. e.*, upon the completion of the cycle) the transfer of caloric occurs.

When a gas passes without change of temperature from one definite volume and pressure to another, the quantity of caloric absorbed or emitted is always the same, irrespective of the nature of the gas chosen for the experiment.

The difference between the specific heat under constant pressure and the specific heat under constant volume is the same for all gases.

When the volume of a gas increases in geometrical progression its specific heat increases in arithmetical progress.

Of course these last two statements are now known to be incorrect, it being established that the difference between C_p and C_v is a constant for any one gas, but not for all gases; and also that the specific heat of permanent gases is independent of pressure and temperature. These conclusions were obtained by Carnot on account of the erroneous assumption of the materiality of heat. Moreover, the assumption of the change of specific heat with volume led him to incorrect conclusions in other cases.

The deductions from Carnot's work made by Clapeyron are correct by reason of the fact that he used differential equations in the extension of Carnot's ideas. For, although Carnot in considering the energy changes of a body subjected to a Carnot's cycle made the mistake of equating the amount of heat-energy (H) given out by the body during the isothermal change of volume and pressure at the higher temperature to the heat-energy (h) absorbed by the body during the isothermal change at the lower temperature, Clapeyron was correct in his equations because they dealt only with infinitesimal changes in temperature, and hence the difference $H-h$, which is the area included between the two adjacent adiabatics and the two isothermals, is an infinitesimal of the second order as compared with the length of the adiabatic included between the two adjacent isothermals, which was taken itself as an infinitesimal of the first order.

It is fortunate that Clapeyron was mathematician enough to use differential equations in expressing these processes analytically. Indeed, in contrast to Carnot he used such a method wherever he could throughout all his memoirs, and always to good advantage.

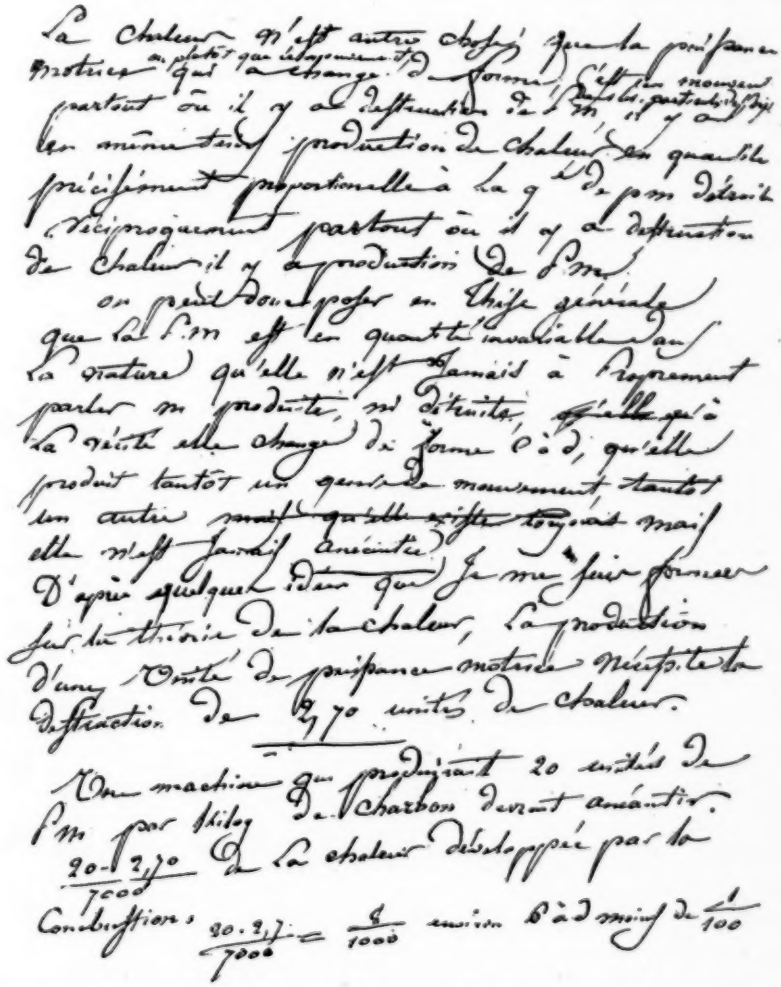
Carnot used the materialistic theory of heat; but it must not be supposed that he was throughout a believer in the same. For even in his memoir as published in 1824 he gives more than a suspicion of its falsity, and in the extracts from his laboratory note-book,* published by his brother after his death, we have direct evidence that he not only foresaw the dynamical theory of heat, but even went so far as to calcu-

* These MS. notes, and also the MS. copy of the 'Reflexions' are on file in the 'Academie des Sciences,' to which body they were presented in 1878 by Carnot's brother, H. Carnot. The notes were entirely unknown to the public until that late date, forty-six years after their author's death.

late the mechanical equivalent and to plan the very experiments since carried out by later workers. To give emphasis to this statement, we have but to consider the following translation of his own words:

Heat is nothing else than motive power, or rather, motion which has changed its form. It is a movement of the particles of a body. Wherever there is a destruction of motive power, there is at the same time the production of a quantity of heat precisely proportional to the quantity of motive power destroyed. Reciprocally, wherever there is destruction of heat, there is the production of motive power.

We can lay down the general proposition that motive power is a quantity



FACSIMILE OF A PAGE OF CARNOT'S NOTE-BOOK RELATIVE TO THE TRANSFORMATION OF HEAT INTO MOTIVE POWER, containing a valuation (the first known to be made) of the so-called "mechanical equivalent of heat." This estimate gives for the mechanical equivalent of heat 370 kilogram-meters, which is nearer the correct value (420, Rowland) than Mayer's later determination (365).

invariable in nature, that it is never, properly speaking, either produced or destroyed. In truth, it simply changes form—sometimes producing one kind of motion, sometimes another; but it is never annihilated.

This is a clear and positive statement of the now well-known 'Principle of the Conservation of Energy'; and yet, by reason of the fact that these notes were not published by their author and did not come to light for half a century after his death, the world awaited the enunciation of this universal principle till the day of Mayer, Helmholtz and Joule. Shall all honor be denied Carnot simply because his work remained undiscovered so long? While we ascribe great and merited praise to those philosophers who were fortunate enough first to present the doctrine of energy to the world, we must not forget him who by reason of the much earlier day in which he lived, made a far greater stride in arriving at the same conclusion.

We complete our quotations by giving some of the passages in which Carnot outlines experiments for determining the mechanical equivalent of heat:

Stir vigorously a mass of water in a small barrel or in the cylinder of a double-action pump, the piston of which is pierced with small holes. Experiments of the same kind on the agitation of mercury, of alcohol, of air, and of other gases. Measure the motive power consumed and the heat produced. . . . Allow air to enter a vacuum or a space occupied by air more or less rarefied; the same for other gases or vapors; examine the rise in temperature. Estimate the error of the thermometer by noting the time taken for the temperature of the air to vary a given number of degrees. These experiments will serve to measure the changes of temperature produced in a gas by changes in volume; they will furnish, among other things, the means of comparing these changes with the quantities of motive power produced or consumed. . . . Allow a quantity of air compressed in a larger reservoir to escape therefrom, and check its velocity by having it escape through a large tube containing a number of solid bodies; measure the temperature when it has become uniform. See if it is the same as that in the reservoir. Same experiments with other gases and with vapor formed under various pressures.

How effectually such experiments did accomplish what Carnot expected is fully attested by the subsequent researches of Joule, Kelvin, Hirn, Regnault and others.

Carnot's work was followed up by the epoch-making papers of Sir William Thomson (now Lord Kelvin) in England, and of Rudolph Clausius in Germany.

The science of thermodynamics, founded on the labors of these three illustrious men, has led to the most important development in all departments of physical science. It has pointed out relations among the properties of bodies which could scarcely have been anticipated in any other way; it has laid the foundation for the science of chemical physics; and, taken in connection with the kinetic theory of gases, as developed by Maxwell and Boltzmann, it has furnished a general view of the operations of the universe which is far in advance of any that could have been reached by purely dynamical reasoning.

SOLOMON'S HOUSE.*

By FRANCIS BACON.

GOD bless thee, my son; I will give thee the greatest jewel I have. For I will impart unto thee, for the love of God and men, a relation of the true state of Salomon's House. Son, to make you know the true state of Salomon's House, I will keep this order. First, I will set forth unto you the end of our foundation. Secondly, the preparations and instruments we have for our works. Thirdly, the several employments and functions whereto our fellows are assigned. And fourthly, the ordinances and rites which we observe.

The End of our Foundation is the knowledge of Causes, and secret motions of things; and the enlarging of the bounds of Human Empire, to the effecting of all things possible.

The Preparations and Instruments are these. We have large and deep caves of several depths: the deepest are sunk six hundred fathom; and some of them are digged and made under great hills and mountains: so that if you reckon together the depth of the hill and the depth of the cave, they are (some of them) above three miles deep. For we find that the depth of a hill, and the depth of a cave from the flat, is the same thing; both remote alike from the sun and heaven's beams, and from the open air. These caves we call the Lower Region. And we use them for all coagulations, indurations, refrigerations, and conservations of bodies. We use them likewise for the imitation of natural mines; and the producing also of new artificial metals, by compositions and materials which we use, and lay there for many years. We use them also sometimes, (which may seem strange,) for curing of some diseases, and for prolongation of life in some hermits that choose to live there, well accommodated of all things necessary; and indeed live very long; by whom also we learn many things.

We have burials in several earths, where we put divers cements, as the Chinese do their porcellain. But we have them in greater variety, and some of them more fine. We have also great variety of composts, and soils, for the making of the earth fruitful.

We have high towers; the highest about half a mile in height; and some of them likewise set upon high mountains; so that the vantage of the hill with the tower is in the highest of them three

* From the 'New Atlantis,' published in 1627. The text of the edition of Ellis and Spedding is followed.

miles at least. And these places we call the Upper Region: accounting the air between the high places and the low, as a Middle Region. We use these towers, according to their several heights and situations, for insolation, refrigeration, conservation; and for the view of divers meteors; as winds, rain, snow, hail; and some of the fiery meteors also. And upon them, in some places, are dwellings of hermits, whom we visit sometimes, and instruct what to observe.

We have great lakes both salt and fresh, whereof we have use for the fish and fowl. We use them also for burials of some natural bodies: for we find a difference in things buried in earth or in air below the earth, and things buried in water. We have also pools, of which some do strain fresh water out of salt; and others by art do turn fresh water into salt. We have also some rocks in the midst of the sea, and some bays upon the shore, for some works wherein is required the air and vapour of the sea. We have likewise violent streams and cataracts, which serve us for many motions: and likewise engines for multiplying and enforcing of winds, to set also on going divers motions.

We have also a number of artificial wells and fountains, made in imitation of the natural sources and baths; as tincted upon vitriol, sulphur, steel, brass, lead, nitre, and other minerals. And again we have little wells for infusions of many things, where the waters take the virtue quicker and better than in vessels or basons. And amongst them we have a water which we call Water of Paradise, being, by that we do to it, made very sovereign for health, and prolongation of life.

We have also great and spacious houses, where we imitate and demonstrate meteors; as snow, hail, rain, some artificial rains of bodies and not of water, thunders, lightnings; also generations of bodies in air; as frogs, flies, and divers others.

We have also certain chambers, which we call Chambers of Health, where we qualify the air as we think good and proper for the cure of divers diseases, and preservation of health.

We have also fair and large baths, of several mixtures, for the cure of diseases, and the restoring of man's body from arefaction: and others for the confirming of it in strength of sinews, vital parts, and the very juice and substance of the body.

We have also large and various orchards and gardens, wherein we do not so much respect beauty, as variety of ground and soil, proper for divers trees and herbs: and some very spacious, where trees and berries are set whereof we make divers kinds of drinks, besides the vineyards. In these we practise likewise all conclusions of grafting and inoculating, as well of wild-trees as fruit-trees, which produceth many effects. And we make (by art) in the same orchards and gardens, trees and flowers to come earlier or later than their seasons; and

to come up and bear more speedily than by their natural course they do. We make them also by art greater much than their nature; and their fruit greater and sweeter and of differing taste, smell, colour, and figure, from their nature. And many of them we so order, as they become of medicinal use.

We have also means to make divers plants rise by mixtures of earths without seeds; and likewise to make divers new plants, differing from the vulgar; and to make one tree or plant turn into another.

We have also parks and inclosures of all sorts of beasts and birds, which we use not only for view or rareness, but likewise for dissections and trials; that thereby we may take light what may be wrought upon the body of man. Wherein we find many strange effects; as continuing life in them, though divers parts, which you account vital, be perished and taken forth; resuscitating of some that seem dead in appearance; and the like. We try also all poisons and other medicines upon them, as well of chirurgery as physic. By art likewise, we make them greater or taller than their kind is; and contrariwise dwarf them, and stay their growth: we make them more fruitful and bearing than their kind is; and contrariwise barren and not generative. Also we make them differ in colour, shape, activity, many ways. We find means to make commixtures and copulations of different kinds; which have produced many new kinds, and them not barren, as the general opinion is. We make a number of kinds of serpents, worms, flies, fishes, of putrefaction; whereof some are advanced (in effect) to be perfect creatures, like beasts or birds; and have sexes, and do propagate. Neither do we this by chance, but we know beforehand of what matter and commixture what kind of those creatures will arise.

We have also particular pools, where we make trials upon fishes, as we have said before of beasts and birds.

We have also places for breed and generation of those kinds of worms and flies which are of special use; such as are with you your silk-worms and bees.

I will not hold you long with recounting of our brew-houses, bake-houses, and kitchens, where are made divers drinks, breads, and meats, rare and of special effects. Wines we have of grapes; and drinks of other juice of fruits, of grains, and of roots: and of mixtures with honey, sugar, manna, and fruits dried and decocted. Also of the tears or woundings of trees, and of the pulp of canes. And these drinks are of several ages, some to the age or last of forty years. We have drinks also brewed with several herbs, and roots, and spices; yea with several fleshes, and white meats; whereof some of the drinks are such, as they are in effect meat and drink both: so that divers, es-

pecially in age, do desire to live with them, with little or no meat or bread. And above all, we strive to have drinks of extreme thin parts, to insinuate into the body, and yet without all biting, sharpness, or fretting; insomuch as some of them put upon the back of your hand will, with a little stay, pass through to the palm, and yet taste mild to the mouth. We have also waters which we ripen in that fashion, as they become nourishing; so that they are indeed excellent drink; and many will use no other. Breads we have of several grains, roots, and kernels: yea and some of flesh and fish dried; with divers kinds of leavenings and seasonings: so that some do extremely move appetites; some do nourish so, as divers do live of them, without any other meat; who live very long. So for meats, we have some of them so beaten and made tender and mortified, yet without all corrupting, as a weak heat of the stomach will turn them into good chylus, as well as a strong heat would meat otherwise prepared. We have some meats also and breads and drinks, which taken by men enable them to fast long after; and some other, that used make the very flesh of men's bodies sensibly more hard and tough, and their strength far greater than otherwise it would be.

We have dispensatories, or shops of medicines. Wherein you may easily think, if we have such variety of plants and living creatures more than you have in Europe, (for we know what you have,) the simples, drugs, and ingredients of medicines, must likewise be in so much the greater variety. We have them likewise of divers ages, and long fermentations. And for their preparations, we have not only all manner of exquisite distillations and separations, and especially by gentle heats and percolations through divers strainers, yea and substances; but also exact forms of composition, whereby they incorporate almost, as they were natural simples.

We have also divers mechanical arts, which you have not; and stuffs made by them; as papers, linen, silks, tissues; dainty works of feathers of wonderful lustre; excellent dyes, and many others; and shops likewise, as well for such as are not brought into vulgar use amongst us as for those that are. For you must know that of the things before recited, many of them are grown into use throughout the kingdom; but yet if they did flow from our invention, we have of them also for patterns and principals.

We have also furnaces of great diversities, and that keep great diversity of heats; fierce and quick; strong and constant; soft and mild; blown, quiet; dry, moist; and the like. But above all, we have heats in imitation of the sun's and heavenly bodies' heats, that pass divers inequalities and (as it were) orbs, progresses, and returns, whereby we produce admirable effects. Besides, we have heats of

dungs, and of bellies and maws of living creatures, and of their bloods and bodies; and of hays and herbs laid up moist; of lime unquenched; and such like. Instruments also which generate heat only by motion. And farther, places for strong insolations; and again, places under the earth, which by nature or art yield heat. These divers heats we use, as the nature of the operation which we intend requireth.

We have also perspective-houses, where we make demonstrations of all lights and radiations; and of all colours; and out of things uncoloured and transparent, we can represent unto you all several colours; not in rain-bows, as it is in gems and prisms, but of themselves single. We represent also all multiplications of light, which we carry to great distance, and make so sharp as to discern small points and lines; also all colorations of light: all delusions and deceits of the sight, in figures, magnitudes, motions, colours: all demonstrations of shadows. We find also divers means, yet unknown to you, of producing of light originally from divers bodies. We procure means of seeing objects afar off; as in the heaven and remote places; and represent things near as afar off, and things afar off as near; making feigned distances. We have also helps for the sight, far above spectacles and glasses in use. We have also glasses and means to see small and minute bodies perfectly and distinctly; as the shapes and colours of small flies and worms, grains and flaws in gems, which cannot otherwise be seen; observations in urine and blood, not otherwise to be seen. We make artificial rain-bows, halos, and circles about light. We represent also all manner of reflexions, refractions, and multiplications of visual beams of objects.

We have also precious stones of all kinds, many of them of great beauty, and to you unknown; crystals likewise; and glasses of divers kinds; and amongst them some of metals vitrificated, and other materials besides those of which you make glass. Also a number of fossils, and imperfect minerals, which you have not. Likewise loadstones of prodigious virtue; and other rare stones, both natural and artificial.

We have also sound-houses, where we practise and demonstrate all sounds, and their generation. We have harmonies which you have not, of quarter-sounds, and lesser slides of sounds. Divers instruments of music likewise to you unknown, some sweeter than any you have; together with bells and rings that are dainty and sweet. We represent small sounds as great and deep; likewise great sounds extenuate and sharp; we make divers tremblings and warblings of sounds, which in their original are entire. We represent and imitate all articulate sounds and letters, and the voices and notes of beasts and birds. We have certain helps which set to the ear do further the hearing greatly. We have also divers strange and artificial echos, reflecting the voice many

times, and as it were tossing it: and some that give back the voice louder than it came; some shriller, and some deeper; yea, some rendering the voice differing in the letters or articulate sound from that they receive. We have also means to convey sounds in trunks and pipes, in strange lines and distances.

We have also perfume-houses; wherewith we join also practices of taste. We multiply smells, which may seem strange. We imitate smells, making all smells to breathe out of other mixtures than those that give them. We make divers imitations of taste likewise, so that they will deceive any man's taste. And in this house we contain also a confiture-house; where we make all sweet-meats, dry and moist, and divers pleasant wines, milks, broths, and sallets, far in greater variety than you have.

We have also engine-houses, where are prepared engines and instruments for all sorts of motions. There we imitate and practise to make swifter motions than any you have, either out of your muskets or any engine that you have; and to make them and multiply them more easily, and with small force, by wheels and other means: and to make them stronger, and more violent than yours are; exceeding your greatest cannons and basilisks. We represent also ordnance and instruments of war, and engines of all kinds: and likewise new mixtures and compositions of gun-powder, wildfires burning in water, and unquenchable. Also fire-works of all variety both for pleasure and use. We imitate also flights of birds; we have some degrees of flying in the air; we have ships and boats for going under water, and brooking of seas; also swimming-girdles and supporters. We have divers curious clocks, and other like motions of return, and some perpetual motions. We imitate also motions of living creatures, by images of men, beasts, birds, fishes, and serpents. We have also a great number of other various motions, strange for equality, fineness, and subtilty.

We have also a mathematical house, where are represented all instruments, as well of geometry as astronomy, exquisitely made.

We have also houses of deceits of the senses; where we represent all manner of feats of juggling, false apparitions, impostures, and illusions; and their fallacies. And surely you will easily believe that we that have so many things truly natural which induce admiration, could in a world of particulars deceive the senses, if we would disguise those things and labour to make them seem more miraculous. But we do hate all impostures and lies: insomuch as we have severely forbidden it to all our fellows, under pain of ignominy and fines, that they do not shew any natural work or thing, adorned or swelling; but only pure as it is, and without all affectation or strangeness.

These are (my son) the riches of Salomon's House.

For the several employments and offices of our fellows; we have twelve that sail into foreign countries, under the names of other nations, (for our own we conceal;) who bring us the books, and abstracts, and patterns of experiments of all other parts. These we call Merchants of Light.

We have three that collect the experiments which are in all books. These we call Depredators.

We have three that collect the experiments of all mechanical arts; and also of liberal sciences; and also of practices which are not brought into arts. These we call Mystery-men.

We have three that try new experiments, such as themselves think good. These we call Pioners or Miners.

We have three that draw the experiments of the former four into titles and tables, to give the better light for the drawing of observations and axioms out of them. These we call Compilers.

We have three that bend themselves, looking into the experiments of their fellows, and cast about how to draw out of them things of use and practice for man's life, and knowledge as well for works as for plain demonstration of causes, means of natural divinations, and the easy and clear discovery of the virtues and parts of bodies. These we call Dowry-men or Benefactors.

Then after divers meetings and consults of our whole number, to consider of the former labours and collections, we have three that take care, out of them, to direct new experiments, of a higher light, more penetrating into nature than the former. These we call Lamps.

We have three others that do execute the experiments so directed, and report them. These we call Inoculators.

Lastly, we have three that raise the former discoveries by experiments into greater observations, axioms, and aphorisms. These we call Interpreters of Nature.

We have also, as you must think, novices and apprentices, that the succession of the former employed men do not fail; besides a great number of servants and attendants, men and women. And this we do also: we have consultations, which of the inventions and experiences which we have discovered shall be published, and which not: and take all an oath of secrecy, for the concealing of those which we think fit to keep secret: though some of those we do reveal sometimes to the state, and some not.

For our ordinances and rites: we have two very long and fair galleries: in one of these we place patterns and samples of all manner of the more rare and excellent inventions: in the other we place the statua's of all principal inventors. There we have the statua of your Columbus, that discovered the West Indies: also the inventor of ships:

your monk that was the inventor of ordnance and of gunpowder: the inventor of music: the inventor of letters: the inventor of printing: the inventor of observations of astronomy: the inventor of works in metal: the inventor of glass: the inventor of silk of the worm: the inventor of wine: the inventor of corn and bread: the inventor of sugars: and all these by more certain tradition than you have. Then have we divers inventors of our own, of excellent works; which since you have not seen, it were too long to make descriptions of them; and besides, in the right understanding of those descriptions you might easily err. For upon every invention of value, we erect a statua to the inventor, and give him a liberal and honourable reward. These statua's are some of brass; some of marble and touch-stone; some of cedar and other special woods gilt and adorned: some of iron; some of silver; some of gold.

We have certain hymns and services, which we say daily, of laud and thanks to God for his marvellous works: and forms of prayers, imploring his aid and blessing for the illumination of our labours, and the turning of them into good and holy uses.

Lastly, we have circuits or visits of divers principal cities of the kingdom; where, as it cometh to pass, we do publish such new profitable inventions as we think good. And we do also declare natural divinations of diseases, plagues, swarms of hurtful creatures, scarcity, tempests, earthquakes, great inundations, comets, temperature of the year, and divers other things; and we give counsel thereupon what the people shall do for the prevention and remedy of them.

And when he said this, he stood up; and I, as I had been taught, kneeled down; and he laid his right hand upon my head, and said; "God bless thee, my son, and God bless this relation which I have made. I give thee leave to publish it for the good of other nations; for we here are in God's bosom, a land unknown." And so he left me; having assigned a value of about two thousand ducats, for a bounty to me and my fellows. For they give great largesses where they come upon all occasions.

NITROGEN-FIXING BACTERIA.

By J. G. LIPMAN,
NEW JERSEY AGRICULTURAL EXPERIMENT STATION.

THE soil may truly be regarded as a vast laboratory. The many processes normally taking place in cultivated soils lead to the gradual formation of plant-food, to the solution of the mineral constituents, to the breaking down of the organic molecules into simpler forms, such that are in a condition to furnish the chlorophyl-bearing plants the material for the building up of plant tissue. The cycle of transformation from the simple to the complex and the falling apart of these complex molecules involve the activity of higher plant life, on the one hand, and that of lower organisms, on the other. Primarily it is the energy derived from the sun that, with the cooperation of the living protoplasm, impels the atoms to enter one or another of the innumerable combinations. These atoms are, as Carlyle would put it, 'but the garment of the spirit,' and the atom of carbon or nitrogen, which to-day is in the leaf of the oak or in the brain-cell of man, may on the next day become a structural part of some bacterial spore that is scarcely visible even with magnification of 1,500 or 2,000 diameters. The different kinds of atoms whose presence is essential in order that living tissue may arise, are not many. Among the less than one dozen of these, it is the migration and transmigration of the nitrogen atoms that undoubtedly form the most interesting, as well as the most important, phase of agricultural research. Of all the elements that enter into the composition of vegetable and animal substances, nitrogen is the most expensive, the most evasive, the most difficult to replace. And every person who at all concerns himself with questions as to the origin and the development of the various forms of life, can not be indifferent as to the source of nitrogen in the soil, and the factors that in one way or another affect the store of nitrogen at the disposal of the living world. Whence is the soil nitrogen derived? What conditions are most favorable for the maintenance of an adequate supply of this precious material? What means have we at our disposal for replacing the losses that occur, that in the nature of things *must* occur?

We should remember of all things, that the great aerial ocean, containing as it does more than 78 per cent. by volume of gaseous nitrogen, does not *directly* offer that element to the plant world. In order that this nitrogen may become available, it must be combined with other

elements. Like Coleridge's Mariner, floating on the sea, surrounded by the sea, and yet perishing for lack of water, so plants growing on the bottom of the aerial ocean, with four fifths of its bulk consisting of nitrogen, and that to a depth of 200 miles or more, would yet starve for lack of nitrogen if there were not means in nature's workshop to combine that very inert gas. Now, soils of average fertility contain rather more than .1 per cent of nitrogen; in other words, the soil taken to a depth of one foot contains 3,500 pounds of nitrogen to the acre. The quantity is not constant, because of the various factors that lead either to the increase or decrease of that treasure hoard which it had taken ages to accumulate. In the processes of decay and fermentation, due to the activity of molds and bacteria, much of the combined nitrogen is set free and is returned to the atmosphere; in all processes of burning and explosion great quantities of nitrogen are again liberated. This latter fact led Bunge to say that every shot fired kills whether it hits anything or not, for it takes away that much life-giving substance from living things. Then again, as the insoluble proteid molecules are broken down and changed into simple salts, the nitrogen that thus becomes soluble, if not taken up by the crop, is leached out of the soil, and ultimately finds its way to the ocean. Enormous quantities of nitrates are thus carried by the streams to the sea, there to feed its denizens, to return, perhaps, in very slight measure to the land, though changed into other forms. Thus the great swarms of coarse fish caught for fertilizer purposes return in their bodies the nitrogen that had once traveled to the sea; thus, also, the still extensive nitrate beds of arid South America are a fractional return of what the sea had taken to itself. That the dissolved nitrates poured into the sea year after year by streams great and small do not remain there as such is clearly evidenced by the analysis of sea-water which shows but traces of nitrates. And so it appears that the soluble nitrogen salt, greedily taken up by plants in the field, is also quickly consumed in the sea. Of course, the nitrate deposits of South America were not deposited from the ocean as such, but resulted from the decay of great masses of seaweed.

Then there are opposite tendencies. There are agencies which lead to the increase of the nitrogen stock in the soil. It was Cavendish who first showed that when electric sparks are passed through air confined over a solution of caustic potash, small quantities of oxidized nitrogen are formed. In a similar manner, the electric discharges in the atmosphere cause the formation of small quantities of combined nitrogen, and Berthelot had shown that silent electric discharges also cause the combination of gaseous nitrogen. Similarly it has been claimed that in the burning of gas, coal, wax, etc., slight amounts of nitrogen become combined. All these factors, and others not mentioned, are, however, of

minor importance as regards the maintaining of the store of combined nitrogen. We should remember that a fair crop of hay will remove from the soil more than 50 pounds of nitrogen, that at times there is removed from the soil 100 to 150 pounds of nitrogen per acre in one season, and remembering that, we can easily appreciate how entirely inadequate the 3 or 4 pounds of nitrogen per acre that are brought down from the atmosphere by dew, rain or snow are for supplying the nitrogen requirements of even a very meager crop.

There must be, then, another factor, or other factors, that are concerned in the supply of the vast quantities of combined nitrogen that are consumed from day to day. The mineral portion of plant food, that portion which constitutes the ash of plants, containing the calcium, magnesium, potassium, sulphur, iron, phosphorus, etc., is derived from the common rocks of the earth's crust. It is otherwise with nitrogen; to be sure, small quantities of it are contained in primitive rocks in iron deposits, in meteoric iron, etc.; yet, speaking generally, nitrogen is not a normal constituent of rocks. It is the atmosphere, and the atmosphere only, which must remain its source for plant and animal life. It is idle to speculate in what condition that nitrogen existed when the earth's crust first began to solidify. It is not likely that it existed as ammonia, for the hydrogen having a greater affinity for oxygen would have combined with the latter. It is not improbable, however, that it existed in combination with oxygen when the temperature of the earth's atmosphere had become sufficiently low. Be it as it may, when the surface rock began to disintegrate and lower plant life first appeared, there was no soil nitrogen. As rock disintegration proceeded, as the rock fragments became finer and offered a more favorable dwelling place for plants and bacteria, the store of nitrogen in the soil began to accumulate. And now we come to those agencies that are of the greatest importance in this gradual increase of the nitrogen store. Small amounts of combined nitrogen formed through electric discharges and brought down to the soil by precipitation would be sufficient in themselves through countless centuries to give rise to vast accumulations, provided that there was a gain only and no loss. But we have already seen that nitrogen is constantly being leached out of the soil. Analytical data at hand show that there is drained away from the land as much as 75 pounds of nitrogen per acre in the form of nitrates, and this certainly is lost to the soil. On some soils the loss is much smaller, on other soils it is even greater, but this, taken together with the amount removed in the crops taken off from year to year, shows clearly that unless there are other means in the economy of nature for drawing upon the great store of atmospheric nitrogen, the present store would soon be exhausted, in fact, it could never have accumulated.

Untiring research by many men and in many places has taught us that it is the mysterious force in living protoplasm that in its aggressive way reaches out and appropriates the restless molecules of atmospheric nitrogen; that though it destroys it also builds up. Practical experience had taught the ancients that crops of the legume family, crops like clover, beans, lupines, etc., do not exhaust the soil to such an extent as do crops not belonging to the same family. They had learned that after a crop of clover they could raise a larger crop of wheat. Why it was so they did not know, nor did the many generations of farmers who followed them; yet not knowing they availed themselves of the advantages that time had pointed out to them. It was reserved for the men of our generation, for men equipped with the methods of our own day, to illuminate the darkness, to unveil for us still another of nature's mysteries, to show us an intelligent way for replacing the unceasing losses of nitrogen. It was scarcely more than fifteen years ago that Hellriegel and Wilfarth published a series of wonderfully conceived and wonderfully exact experiments that decided for all time a much-debated question, which for a century had taxed the ingenuity of the foremost scientists of Europe. What Boussingault with all his mental penetration and clearness of vision had failed to accomplish, what Lawes and Gilbert with all their painstaking care and admirable equipment had failed to achieve, the German investigators had made clear. They showed conclusively that in the root nodules of leguminous plants there are found certain bacteria that in a way still unknown to us enable the host plant to make use of the gaseous atmospheric nitrogen. We do know that there is a continual struggle between the plant and the invading bacteria; we are justified in believing that the bacteria, compelled by the plant, unlock to it the hitherto inaccessible store of nitrogen. It was in this wise, partly, that the nitrogen accumulation in our soils resulted; it was in this wise that the rich prairie soils, containing at times as much as twenty thousand pounds of combined nitrogen per acre to a depth of one foot, had acquired that nitrogen. This dwelling together of two distinct forms of life with mutual benefit resulting is known as symbiosis, and the symbiotic life of leguminous plants and of the organism known as *Bacillus radicicola* has made possible to a great extent the terrestrial life of to-day. Yet there is another phase of the question, a phase that but a few years ago had not been recognized. There are bacteria in the soil that can avail themselves of atmospheric nitrogen without the aid of leguminous plants. Recent work in this field of research indicates that such fixation of atmospheric nitrogen is of vast significance, of greater moment, perhaps, than the fixation of nitrogen by legumes. To understand more clearly the relations existing among the many

forms of bacterial life that are concerned with the transformations of the soil nitrogen it is necessary to consider separately some distinct phases of the nitrogen question. The plant tissues from which life had departed hold in them the nitrogen that had once moved in soluble form through the soil. The nitrogen in the dead plant tissue can not, however, again become a part of the food for other plants; not until it has again been changed into simpler soluble forms. This locking up of the nitrogen in forms slowly decaying, and therefore slowly available, is a wise provision, otherwise the nitrogen would soon be washed out of the soil. Thus we see that the soil nitrogen is contained in an insoluble form in the remains of former plants, and, no matter how much of it the soil contains it is inaccessible to the plant growing upon it until it has been first changed into the simpler forms. Now, as to the agents that produce this transformation. Bacteriology, in general, and soil-bacteriology, in particular, are subjects to which the attention of the scientific world has turned very recently. Of the many hundreds of different species of bacteria living in the soil, but few are known. Nevertheless, even at the present time, enough has been learned to enable us to form a conception, at least, of the changes that take place there. The nitrogen of organic substance, whether plant or animal, usually exists in the form of albuminoids, more frequently termed proteids. These proteid molecules are seized by the soil bacteria and are utilized by them for the formation of their own bodies. Being saprophytic by nature, that is, unable to build up organic substance from the simpler materials, as is done by higher plants, they must derive their energy from the tissues that chlorophyl-bearing plants had fashioned with the aid of sunlight. In availing themselves of this potential energy for their own purposes, they break down the complex molecules; to use a popular expression, they cause decay. In order to gain their end, that is, to secure the food contained in the proteid molecules, the bacteria must first change it into a readily diffusible, soluble form. For this purpose the chemical ferments known as enzymes are produced. With the aid of these enzymes, the albuminoid substances are 'peptonized.' In the laboratory such organisms are described as gelatin-liquefying bacteria. A part of the food thus made accessible is appropriated by the microorganisms and in their physiological processes is still further simplified. A part of the carbon is oxidized and escapes into the atmosphere as carbon dioxide, gaseous hydrogen or oxygen is set free, or the two are combined to form water. The nitrogen with which we are here concerned is subject to many changes. In the course of its migration it forms a part of the amid molecules; from these it is split off in the form of ammonia, and this again may be destroyed and gaseous nitrogen set free, or seized by another distinct class of organisms, and oxidized to nitrites

and nitrates. The last is the form in which the nitrogen is usually taken up by the plants. On the other hand, the nitrates are themselves subject to the opposite forces of deoxidation. There are species of bacteria in the soil which reduce nitrates to nitrites, to ammonia or even to gaseous nitrogen. To recapitulate, then, there take place in the soil processes of nitrification, denitrification and also the fixation of free nitrogen. It was necessary to consider the former two, in order to understand the third. It would be out of place here to speculate upon the manner in which the soil nitrogen is oxidized; it might not be out of place here to consider the possible ways in which nitrogen is set free from its compounds, on the one hand, or is 'fixed,' on the other hand. Quite recently hypotheses have been advanced which would regard the processes of 'fixation' and of 'denitrification' as being very much related phases of the same physiological activities. The investigators who have labored in this field of research, and to whom we owe most of our knowledge on the subject, are Berthelot, Winogradsky, Beyerink and Stoklasa. Berthelot was among the first to observe that soils free from vegetation can increase their store of nitrogen. Winogradsky, after much painstaking search, isolated from the soil an organism, which, in company with two others, can grow in nitrogen-free media and fix considerable quantities of nitrogen in a short time. Beyrink, also, has isolated within the last few months several organisms that possess a similar power, and Stoklasa has done a great deal of careful work to determine just how the fixation of nitrogen is accomplished. Moreover the subject has assumed more than a mere scientific interest within the last three or four years. The firm of Friedrich Bayer and Co., of Elberfeld, Germany, has placed on the market a bacterial culture bearing the fancy name of 'Alinit.' This alinit they claim can under favorable conditions increase the yield of non-leguminous crops 40 per cent. On examination, the alinit proved to be a pure culture of *B. ellenbachii,* mixed with a starchy material resembling dried and pulverized potatoes. The organism was isolated by a German gentleman-farmer, Caron by name, and named *B. ellenbachii* after his estate, Ellenbach. This bacillus differs but little from the organism isolated by Du Bary some years earlier, and called by him *B. megaterium.* This organism, Stoklasa claims, is not only similar to, but identical with *B. ellenbachii.* The accumulated evidence of several investigators on this point inclines me to the belief that the two are not identical, though very much allied. At any rate, Stoklasa has shown that *B. megaterium* is capable of fixing atmospheric nitrogen in media containing but traces of fixed nitrogen; it develops and adds to the nitrogen content of the medium by drawing upon the nitrogen of the air. This organism has, as it were, a double nature. In the first place, as just noted, it is capable of fixing atmospheric nitrogen; in the second place, it exerts

a deoxidizing effect when grown in solutions containing nitrates, with the production of nitrites and ammonia. This double action leads us to inquire into the nature of the physiological processes taking place in either case. His investigations in this field led Stoklasa to assert that there is much in common between the two processes. He believes that the deoxidation of nitrate is due to the action of the bacteria on water, with the liberation of hydrogen and the formation of hydroxyl. Nascent hydrogen is a powerful reducing agent, and would of itself withdraw the oxygen from nitrates to form nitrites, while hydroxyl in contact with ammonia will cause the formation of water and the liberation of nitrogen. Part of this nitrogen is undoubtedly utilized by the bacteria, and the rest is returned to the air. How the inert nitrogen molecule is torn apart and the nascent nitrogen atoms thus formed utilized by the bacteria for their growth is a question that is more difficult of solution. We do know that the amount of nitrogen fixed by *B. megaterium* is affected by the composition of the nutritive medium. The same is true of denitrification. The molecular structure of some carbohydrates or of organic acids and the arrangements of the atoms in the molecule influence the activity of the bacterial cell and its life processes. I have found, for instance, that the more complex citric acid molecule offers a more favorable source of energy to a denitrifying organism that I have isolated than do either succinic, tartaric or lactic acid. And the laboratory work clearly indicates that the amount of organic substance in the soil, as well as its nature, determines the course of development, and the prevalence of the one or the other of the soil organisms. Certain it is that where the fixation of nitrogen takes place in the soil, it occurs only when its store of nitrogen is very meager. This is analogous to the behavior of the legumes. It has been found that these plants when growing in a soil rich in soluble nitrogen do not to any considerable extent draw upon the atmosphere for that element. It is only when the soil offers little or no nitrogen that the atmospheric treasure house is unlocked for it. All experimental evidence thus far accumulated indicates that there is a struggle between the plant and the bacteria invading its roots, that the latter are so modified by the aggressive activity of their host that they form a fine network of tissue in which the atmospheric nitrogen is captured, as it were. That this assumption is not entirely erroneous is shown by the fact that legumes, inoculated with cultures of *B. radicola* that are particularly virulent, although they form root tubercles, show nitrogen hunger when there is none in the soil at their disposal, and the microscopic examination reveals bacteria that are not modified as is the case in vigorous plants. In other words, the bacteria resist the encroachment of their host and would not be compelled to furnish it with the nitrogen that it can not get otherwise. In connection with this, the question naturally

arises whether *B. radicola,* the bacteria of the legume tubercles, can fix atmospheric nitrogen independently of its life in the legume tubercles. As a matter of fact, Beyerink and Mazè claim to have proved that this organism can fix elementary nitrogen independently of legumes. We should note here the remarkable fact that although this organism is so universally distributed and common in all soils, all attempts to isolate it from the soil directly have not been successful.

There are probably a half a dozen bacteria capable of fixing atmospheric nitrogen known to-day, and there is little doubt that others will be found before long. As it is, we are fully justified in the claim that soil bacteria are a potent, nay, an indispensable, factor in the creation of the world's food. Though they are to most of us an invisible world, though many of us never suspect their existence, they are yet our staunch friends, living their brief life, contributing to a broader life, making it possible for the finite to dream of the infinite.

SOME ARACHNIDS AT HANOVER, CAPE COLONY.

BY S. C. CRONWRIGHT SCHREINER,
HANOVER, CAPE COLONY.

WHEN I left Cape Town for Hanover, my friend, Dr. Purcell, of the South African Museum, the leading South African authority on spiders and their kin, asked me to send him any of these creatures I might capture. The district of Hanover, he said, and indeed, practically, the whole high Karoo plateau, was unexplored arachnologically; there had been no collection from the high plateau, and he was particularly anxious to have one to compare with the arachnid fauna of the lower-lying Great Karoo.

I have devoted special attention to spiders, Solifugæ and scorpions, though, naturally, other things have found their way into the collecting bottles. These have all, from time to time, been sent to Dr. Purcell for classification, and the results have been, on the whole, as surprising as interesting.

If the reader will take a map of the Cape Colony and follow the railway from Cape Town to Bloemfontein, he will find the little station of Hanover Road lying about midway between De Aar and Naauw Poort Junctions. Nine miles across the veld, southwest from Hanover Road, is the little dorp or village of Hanover, which lies at the foot of two ijzer (iron-stone) kopjes, on a great Karoo flat, 4,700 feet above the sea level. A superb fountain gushes out from a covered furrow at the foot of the kopjes, furnishing an abundant supply of water for the houses and the fruit gardens; a great vley runs east and west past the dorp; groups of kopjes dot the mighty veld at intervals, and purple hills and mountains fringe the clean-cut and distant horizon. Hanover is bare and at times very cold in the winter; but, in the summer, when the willow trees along the water furrows that line the streets, and the fruit trees in the gardens about the white houses, are green, the little dorp is, of all small towns I have seen, by far the most beautiful. It lies like a great flower on the brown Karoo—not as an excrescence, but as though it were part of the veld. There are old men here who have seen lions in the neighborhood, and younger men who have seen wildebeeste (gnus) career through the streets.

My collecting has been confined practically to the commonage in the immediate neighborhood of the dorp, over which, under martial

law, I have had a permit to walk. But fortunately the Dutch farmers have been interested in my work, and both adults and children have gladly taken bottles of spirits and collected on the farms. I have thus received many interesting specimens of spiders and Solifugæ. The farmers are pleased that so many new things have come out of their district, and are eager that it shall hold a front place in the great museum at the capital. A gray-headed old man handed me a bottle of spiders the other day with the remark 'Ik denk Hanover is nou zeker vóór' ('I expect Hanover is in front now'), and was much pleased when I told him how well Hanover was holding its own at Cape Town. The school children too, especially the girls, have done well. I have a couple of charming young friends who, in three weeks, sent me over three hundred specimens, some new and of great interest.

The result of the collecting up to the time of writing is, that, out of over two thousand arachnids I have sent to the museum (and excluding some spiders still undetermined), Dr. Purcell has found some twenty-one families of spiders, comprising more than a hundred species (the great majority of which are new to science), some ten species of Solifugæ (several of which are also new to science), four species of scorpions and one pseudo-scorpion.

One can not speak with any certainty yet, but it would almost seem that the high plateau has, largely, its own peculiar arachnid fauna, which, if it be so, is a very interesting fact.

But the interest does not lie wholly in the finding of an apparently new fauna and many new species of very rare genera; it is perhaps greatest in connection with what has been learned concerning spiders whose habits were thought to be known.

Before passing on to the arachnids, one or two interesting finds in other orders may be noted.

Among snakes, a small rare species (*Prosymna sundevalli*)—speckled, handsome and non-poisonous—is remarkable as having a hard snout for burrowing into the ground. Another snake is interesting from the manner of its capture. I was reading one evening inside the house and my wife was walking up and down the stoep after the heat of the day, when I heard her call anxiously. I went out and found the snake, which I killed two feet from our open door, for which it was making. A beautiful family are the Kous slangen (garter-snakes). They are very poisonous, but fortunately they are smallish and have very small teeth. The best specimen of these snakes I have caught is perhaps the most beautiful of them all. It is circled throughout its whole length with alternate bright red and deep black bands about half an inch wide. I nearly trod on it, and was warned by the most violent short hisses. I looked down at my feet, and there, standing up on a red iron-stone, was this enraged and lovely

creature, swaying to and fro with flattened head, ready to fight. It looked like the gay stalk of some beautiful aloe; and its beauty and pluck so appealed to me that I captured it only with great reluctance.

Of course, the kopjes and the flats abound with various lizards, some of the most gaudy colors. For instance, there is one with spiked coat and rough, ringed tail, which has a red head, blue throat, neck and sides, while the back varies from red to brown towards the tail. It sits on a rock and quaintly raises itself up and down on its forelegs. If danger approaches, it slips into a crevice, from whence it can hardly be taken alive, for the spikes catch on the stone so firmly that the lizard is able to resist almost all attempts to take it out. But most interesting, perhaps, are the Geckos (*Pachydactylus mariquensis*), which the Dutch call getjes, also generally found under stones. They are about six inches long and not so quick in their movements as lizards usually are. This and their defencelessness have induced a peculiar method of protection. Their fleshy tails are quite loosely affixed, being deeply constricted all round where they join the body. A slight touch will break them off—so much so that at times the getje seems almost to *throw* them off. Then is seen a strange thing. The tail jumps about in the most lively manner, and thus attracts the attention of the pursuer, while the getje quietly and unobtrusively moves away unobserved—and goes and grows another tail! This is a peculiar and yet very effective method of protection; there are other local lizards that part with their tails with comparative ease, but they are quicker in their movements and their tails are not nearly so lively; the method has reached perfection in the case of the getje only. I am generally accompanied in my walks by my wife's little fox terrier. She seldom catches a getje. When she jumps at one, off flies the tail, which she invariably seizes as it plunges frantically about, and the getje escapes. The getjes are of various colors, some very handsome. Some kinds burrow holes in the sand, and these occasionally take possession of deserted nests of the large trap-door spiders. (I say deserted; they may, however, kill the spiders; but I do not think they do.) They somewhat narrow the opening of the tube just under the lid, to about the size of their body, but they leave the lid intact and keep it in use, opening and shutting it (or allowing it to shut itself) at will. On lifting a lid on one occasion, I found the getje in the hole, peering out from under the slightly-gaping lid, with its head just level with the surface of the ground—a very odd sight. I dug down, and at the bottom of the hole found its egg, which it was evidently guarding. On another occasion I found two at the bottom of a large closed trap-door nest. The lid of a nest, when occupied by the getje, does not close so perfectly as when occupied by the spider, due perhaps to the narrowing of the opening. Though

generally held to be poisonous, these charming little lizards are really quite harmless. Hottentots have a great dread of the getje, believing that if it bites them, they will live just long enough to reach home, or at most till sundown.

Among this miscellaneous collection is a wasp (*Mutilla*), of which I have found some twelve or fourteen kinds. The males are winged, as usual with wasps, but the females are wingless. She has a red thorax and a yellow-spotted hairy abdomen. She runs very quickly among the karoo bushes, and, if alarmed, hides under them or buries herself in the loose hot sand at their roots. She has to be handled carefully, as she has a very powerful sting. She also stridulates, no doubt a call to her flying mate who, by the way, cannot sting. I have found only three males (one dead in a *Stegodyphus* nest), but the males are very rare. I do not know why the females are wingless and the sexes so different in appearance. But the same thing occurs with some grasshoppers; I have one kind particularly in my mind, the female of which is dark, huge and heavy, with only rudimentary wings, while the male is small, slight, smart, brick red and a splendid flyer. The variety of grasshoppers and ants here is extraordinary, and the protective shapes and colors are most wonderful. Such protective devices are, of course, quite a feature of the fauna of the bare and stony karoo; but no one who had not seen them could believe how efficacious they are. Even a trained eye may lose an insect while looking at it.

Passing on to scorpions, the four species found here embrace three genera. One kind (*Opisthophthalmus austerus*), a burrower, is very common; one may catch fifty almost any day. They grow to six or seven inches in length and are pugnacious and poisonous. Most *Opisthophthalmi* dig holes from one to two feet deep, sometimes but not generally under stones, with the opening oval-shaped like a human eye; but *O. austerus* here is, as far as my experience goes, invariably found under stones by day, sometimes with only a shallow burrow under the stone, at other times with a burrow ending in a hole which varies in depth, often not being deep enough to hide the scorpion. When you raise the stone you expose the scorpion, which runs to and fro in its now roofless burrow, and, if it has sunk a hole, eventually dives down into that, sometimes tail first. If you irritate these scorpions, they tilt the hind part of the body forward and up by straightening their hind legs under it; then jerking it quickly and stridulating angrily, they rush at you; and most ugly creatures they are—all nippers and sting. The stridulating sound is produced by rubbing the jaws which are lined with short, stiff, yellow hairs against the front edge of the head-plate. The male closely resembles the female up

to the last molt, but after that he is longer and slenderer and has longer and slenderer hands (nippers), but he is quicker and more vicious. *O. austerus* is handsomely marked; the back is dark brown, the sides purple sometimes greenish, and the hands often a rich mixture of red and brown. Scorpions have an organ, like two small delicate white wings, attached underneath the body between and in a line with the last pair of legs, which in the male is toothed along the back edge to the base, while in the female the last quarter is not toothed; its functions are unknown, but it is some delicate sense organ presumably.

The other kinds of scorpions found here do not call for special remark, though it may be noted that one of them (*Parabuthus neglectus,* Purc.) was not thought to occur so far east. There is, however, a very interesting pseudo-scorpion, a small tailless creature, otherwise much like a scorpion, found under stones and in sand, which has the curious habit of burying itself in the sand, and then, when it wishes to change its quarters and opportunity offers, it seizes a bee or fly by the leg and is thus strangely transported through the air by the flying insect.

Scorpions are of course viviparous and carry their young when small on their back.

The next group, the Solifugæ, is a very interesting one. The Dutch call them Jacht Spinnekoppen or Haar Scheerders, and, as usual, these are the names by which the Solifugæ are generally known in South Africa. Except that the Solifugæ are not spiders (though, outside of scientific circles, held to be so in South Africa), Jacht Spinnekop (hunting spider) is a very appropriate name, for, to the casual observer, they resemble spiders, and they are mighty hunters. Haar Scheerder (hair shearer) is even more appropriate. They are called Haar Scheerders because of their two enormous 'shears.' Many a person believes that, if they get into your hair, you will not get them out again until they have shorn it all off; others believe that they wait until you are asleep and then come and cut your hair off to build their nests with—imaginery operations, suggested no doubt by the name and the shape of the jaws.

I know of no creature which, for its size, is so terribly armed as the Jacht Spinnekop; practically the whole of its huge head is transformed into two pairs of terrible nippers of quite extraordinary size and power. These nippers run straight forward, the eyes being placed just where they emerge above. Each pair of nippers has its own independent nipping action, and, in addition, each has an independent up-and-down and backward-and-forward motion, giving the jaws an awful tearing power, so that, as soon as the prey is seized, it is ripped into pieces.

The 'Tommies' along the railway sometimes make one of these creatures fight with a scorpion. They place the combatants in some slippery vessel so that they can not run out. The scorpion is nearly always much the larger and heavier and has, in addition to its long arms and powerful nippers, a deadly sting. Yet it not infrequently happens that the Jacht Spinnekop comes off victorious, for it seizes the scorpion in its terrible shears and tears a huge hole in it with a quickness and force against which the scorpion is often powerless.

I have a fine large one before me as I write, nearly three inches long (from tip of jaws to end of abdomen), whose jaws alone are more than a quarter of its length, and are, across in front of the eyes, the broadest and solidest part of the whole creature. It is not poisonous; it needs no poison with such terrible jaws.

Passing from the most obvious feature of the Solifugæ, one remarks several other unique characteristics. In spiders, there are, in front of the first pair of legs, two feelers, one on each side of the head, called palps, shorter than the legs, except in very rare instances; in the scorpion, these palps become long arms with powerful nippers at the ends, and there are no delicate feelers; in the Solifugæ, these palps become long, stout and leg-like, with suckers at the ends for holding or climbing, while there is the very interesting further development that the first pair of legs have ceased to be legs and have become thin, delicate feelers. But there is yet another development, if possible even more interesting still. Along the lower side of the last pair of legs are little white oval plates, supported at regular intervals on short stalks. These delicate little pedestals are sense organs of unknown function; it is possible they are organs of scent, enabling this great hunter to track his prey as he rushes along on the spoor.

Of the Solifugæ I have found some ten or twelve kinds, some belonging to genera hitherto very rare in South Africa. *Dæsia* is the rarest of the known genera here, and the local species is new. The first male found was only the second of the genus in the South African Museum collection. *Dæsia* is smallish and of a light, almost transparent, yellowish tint, and nocturnal in its habits. By day one finds them (if lucky enough to do so) under stones. *Blossia,* of which the species found is also new, is smaller than *Dæsia* and of a delicate pink color; of these I have found several females, but only one male. Another form is a tiny black one, belonging to an undescribed species and genus, and not more than a quarter of an inch long.

But I pass on to the genus *Solpuga,* in which the large kinds, diurnal and nocturnal, are found. When one first sees one of them on the veld, especially the commonest (*S. chelicornis*), one can hardly believe it is not a beautiful karoo flower. This *Solpuga* is about two

inches long (exclusive of legs) when full grown, and of a most brilliant yellow, with a heavy black band down the back of the abdomen, while the legs are covered with long yellow hair, which, in the male, becomes a distinct mane and is iridescent. As it lies on the sand on a hot day, sparkling in the sunshine, it is a most exquisite creature. Touch it, and away it darts; catch it—and take care it doesn't catch *you!* The male of this *Solpuga* may be distinguished from the female by two little curved horns, like wires, more than a quarter of an inch long, one on top of each pair of nippers near the points. If you watch a *Solpuga* closely, you may see its sides palpitating rapidly, even violently if you hold it in your hand. Like all active, high-strung, quick-breathing creatures, the Solifugæ perish almost instantaneously when immersed in spirits, while large scorpions and large Harpactiræ will live for two or three hours. Another *Solpuga* has a yellow cephalothorax and a red abdomen, another is wholly yellow with spikes on its legs.* Very little is known with regard to their methods of reproduction and the nurture of their young. They are great burrowers, but do not make regular holes apparently, and they lie dormant underground during the winter. They are a feature of the thirsty veld and the blazing sun.

Coming now to spiders, and dealing first with the four-lunged group, one may remark that the lung plates are very obvious as four yellowish or pinkish discs on the fore part of the lower side of the abdomen (as are the two discs in the two-lunged genera). The largest here are the Theraphosidæ, known in South Africa by the Dutch name, Baviaan Spinnekoppen (baboon spiders). I have been able to discover only one kind here, a new *Harpactira.* The adults, with their legs extended, are roughly as large as a man's hand. Their huge bodies and long powerful legs are covered closely with long hair, which is almost identical in color with the hairy coat of a baboon—hence, perhaps, the appropriate name; putting aside the fact that baboons, who turn stones over in search of scorpions and insects of various kinds, are said to be very partial to them. They are poisonous and have very large and powerful fangs directed backwards and subparallel. When these fangs, which ordinarily lie tucked backwards under the cephalothorax, are shot forward and opened apart, the huge hairy spider has a dreadful appearance. The pads on the legs (extending along the lower side of the two end joints and over the tips) are soft and clingy, like the skin of a monkey's hand, and iridescent. Baviaan Spinnekoppen are nocturnal, living by day under stones in

* These two species, and possibly one or two others, are probably new, but this cannot be determined for certain until the males are caught, and, as yet, I have caught only the females.

burrows, which sometimes end in a hole or a cup-like depression in the ground and are beautifully lined with soft, white silk. Very large spiders are nearly always under large heavy stones; one might almost say that the size of the stone varies as the size of the spider. They prefer the stones on the flats or rands or the boulders at the foot of the kopjes. Occasionally they sink a hole an inch and a half in diameter in the open karoo soil and spin strands of web across its mouth. In one such hole I dug up an adult female with her numerous young, and it was a curious sight to see the young swarming over the great spider. The hole dropped perpendicularly for about six inches and ran at right angles for another foot. The lairs of these spiders are always strewn with bodies of beetles, large and small, eloquent evidences of the sad tragedies that are enacted in insect life. The new *Harpactira* is common at Hanover, though one does not often find really fine examples of adults. The adult males are rarer than the females, from which they may be distinguished by their slighter bodies and longer legs and by a peculiar pear-shaped spine at the ends of the palps.

We now come to the regular trap-door spiders, the Ctenizidæ, that sink a cylindrical silk-lined tube into the earth and affix a hinged lid to the opening. Of these I have found seven species, all of them, I believe, new. Perhaps the greatest interest gathers round a new *Hermachastes.* At Cape Town, the representative of this genus has hitherto invariably been found by Dr. Purcell with a trap-door to its hole, but the Hanover species has made a new departure. I have dug up over a hundred, I should think, and have never yet found one with a door. Some have escape blind side chambers, but I have been unable to find a door, either inside or outside. On the contrary, they have the uniform habit of building up a tube with irregular rim, projecting above the ground and varying in height from being just perceptible to a perpendicular regularly cylindrical funnel about an inch and a half high, the average height being more than half an inch. These projecting tubes are built of leaves, pieces of grass or small sticks, and are bound together and lined inside with white web, which extends throughout the length of the underground hole. This habit, as far as regular trap-door spiders are concerned, was, up to this discovery, quite unknown in South Africa; though I believe there are trap-door spiders in northern Africa which apparently build a similar projecting tube. I have not yet found the adult male of this *Hermachastes,* which probably lives under stones by day—a habit common to the males of this family; but the making of the nest as described has been established with regard to adult females, males up to the last molt, and the young of both sexes.

What has made this spider abandon its trap-door nest and adopt the projecting tube habit? The karoo is dry and dusty and wind swept, and so one can easily understand why an underground, doorless hole should have a projecting funnel; but this will hardly account for the abandoning of the trap-door.

One may note, however, that one of the most common spiders here is a *Lycosa* (*L. subvittata*) which sinks a hole in the ground with projecting tube with irregular rim. A trained eye can generally detect the difference between these two nests at a glance, though sometimes even such an eye will be at fault; but, to the untrained eye, the projecting tubes are so much alike that they are, in the majority of cases, indistinguishable. Now, this *Lycosa* belongs to a wholly different family of spiders, in the two-lunged group; it is a less handsome, smaller spider, pugnacious when handled and remarkably active and wary—unlike *Hermachastes,* which is slow and dull. Can it be a case of imitation, and that *Hermachastes* has adopted the habit of building a nest like *L. subvittata* in a part of the country where this tube-building *Lycosa* is common all over the veld? The interest deepens, as will be seen, when I come to describe the habits of another *Lycosa.*

There is another trap-door spider, *Hermacha* (also a new species), closely allied to *Hermachastes,* which also has a doorless hole but no projecting tube. Its hole, which is sometimes ten inches deep and beautifully lined with white silk, just ends straight off, level with the surface of the ground. Frequently, however, the opening has a delicate, smoke-like web curtain spun across it, which effectually prevents dust getting into it and bars the way to such enemies as do not dig the spider out. Dr. Purcell thinks this habit may be merely the spider's way of shutting itself in when moulting, but it seems to me to occur too frequently and the inmate to be too lively for the acceptance of such an explanation. *Hermacha* builds in stiff clayey (brak) soil, which cakes like a stone when dry. When dug up, it shows fight, rearing itself up, raising its legs, and throwing forward and parting its fangs so that a bright red gap is exposed between them. The nest of *Hermacha* was unknown until I found it here.

Passing by several new and interesting species of this family, we come to perhaps its most representative members, the large spiders that make the largest and strongest doors. Of these I have found three species here, two new *Stasimopus* and one new *Gorgyrella* (a new genus, recently named by Dr. Purcell.) These two forms are closely allied and superficially bear a strong resemblance to each other, except that, generally, *Stasimopus* has a darker cephalothorax and legs. They are slow in their movements, large, with powerful digging teeth and stout, strong, shortish legs. Their silk-lined holes are prac-

tically alike, generally dropping almost perpendicularly into the earth for about six to nine inches, with the opening a little larger than the rest of the cylinder; but the doors are different. *Stasimopus* has a thick cork-like door, with bevelled edge, which fits into the hole, being a little larger at the top than at the bottom. The thickness of the door of *Gorgyrella* varies; sometimes it is cork-like (though not so thick as the thickest *Stasimopus* lids), and, at other times, thin and not so firm and solid, in which case its bevelled edge is not so pronounced, and it more overlaps the edge of the hole. The lids of both are always on bare ground, covered with earth, and just flush with the surrounding surface. But there is one essential, and, as far as my experience goes, constant variation in the lids; that of *Stasimopus* is round, with a slighter hinge, which does not apparently break into the outline of the circle, while that of *Gorgyrella* is an incomplete circle, more or less D-shaped, with a broad, strong hinge. In the case of both, the silk that forms the hinge is so arranged as to act as an elastic spring which closes the door automatically. (The nest of *Gorgyrella* was unknown until I found it here, but I have sent some good specimens—as well as many other nests—to the museum, where they may be compared with those of *Stasimopus;* the spider itself is unrepresented—or at any rate unrecorded—in any European museums.)

It is only the females and young that build these nests; the adult males of the whole family are supposed to live under stones. Both sexes are nocturnal in their habits. The females are common but difficult to find; the males, however, are extremely rare; the male of *Gorgyrella* has never yet been found. I found one male *Stasimopus,* which was the second specimen in the South African Museum collection, only one other specimen—that in the British Museum—having been recorded previously. He is hardly recognizable as being what he is, for he is small (about half an inch long), black, with greatly elongated palps. He cuts a very diminutive figure beside his huge and powerful consort.

Among my *Gorgyrella* finds recently have been two with cocoons and one with young. It would seem that, when the eggs are laid and until the young are strong, the female shuts herself up in the hole; for in all three cases I found the lid closed down securely. The hole containing the mother and young was actually so fastened down that I had to tear it open all round the edge. I am not sure that the other two were also stitched down, but the ground had caked round the edges, effectually fastening them down.

These nests are difficult to discover, indeed almost impossible, except after rain, when, if you know where to look and what to look for, you may find a good many; for the holes being hollow, the lids

dry before the surrounding earth and show as lighter colored discs.* One needs a little practice, however, even then. The spider is generally at the bottom of the hole, but sometimes, when she hears anything stirring at the lid, she rushes up, digs her claws into it (the lid of *Stasimopus* has a double circle of holes on the inside, into which the claws are inserted), presses her body against one side of the tube and her legs against the other, and holds the door shut with a strength that is simply amazing. Then you may dig her out easily, by removing only a couple of inches of the tube. If you take the piece of earth which contains the spider holding the door shut, and prod her from the back, she will rush partly out of the door and look around, but she generally keeps a claw of a back leg fixed in the lid, by means of which she can, up to the last moment, withdraw herself again like a flash, so that you may occasionally hear the door *slam,* if you have good ears and listen carefully! I once hurriedly tried to drag one away while she had her claw fast in the lid, and she parted with her leg rather than lose her last chance of retreat. When she does let go, the door closes of its own accord by means of its spring hinge.

Their chief enemy here is a burrowing animal, a 'mierkat' (*Suricata tetradactyla*), I think, which destroys a great number of them, discovering them by scent, no doubt.

Some South African trap-door spiders have become climbers. The family Migidæ have, in some instances, become tree trap-door spiders, where they are safe from some of their hereditary enemies and are equally well off for food. They build oval sack-like nests, one to two inches long, under stones or on trees, and cover them externally with moss, lichens, etc., and place a trap-door at one end—a very interesting adaptation. I have found one new species of the genus *Moggridgea* here, but have not yet discovered its nest.

Coming now to the two-lunged spiders, with opposite fangs (which comprise the great majority of spiders), a notable one is *Latrodectus,* which has the most evil reputation in South Africa. It is black with medium long legs and a globular abdomen. (The male is much the smaller and has a thin abdomen.) Fortunately this poisonous spider has a warning color, a red flag showing danger at hand! On the back of the abdomen she has a bright red spot (or spots or stripes). She builds a bell-like nest, about three inches long, in a small bush. At the bottom of the bell, which hangs mouth downwards, the web is very fine and open, and from the mouth radiate web strands. As the webbing approaches the top of the bell, it becomes closer woven, until, for about the last inch or so, it is quite opaque and often cov-

* This method was suggested by Mr. Charles Groom.

ered with small stones, some of them astonishingly large in proportion to the size of the spider, which she has carried up one by one from the ground. There the deadly spider lurks invisible. If you touch the nest, she rushes out, a beautiful creature, with the red patch blazing on her back like fire.

A charming little spider is a *Nemoscolus* (one of the Argiopidæ), which makes a curled nest just like a tiny bugle, within which she lurks. If you walk over the flats, you will see these little bugles suspended upright, mouth downwards, on the karoo bushes, about a foot from the ground. The 'bugle' is kept in position by means of about five powerful strands, tightly strained in different directions, and from its mouth radiates a beautiful little geometric web, hung over the ground like a tiny parasol. If you take hold of the bugle, the spider rushes to its mouth, gives a quick glance round, and then drops to the earth like a plumet, where she lies, feigning death, and is by no means easy to discover.

Another genus of the same family is *Argiope,* which spins a good-sized geometric web with a light pyramidal tangle below it. A favorite site is the open mouth of an ant-bear hole. She sits in the middle of the web, back downwards. The abdomen is large, and somewhat flat with deeply serrated edges, and both it and the cephalothorax, which is slight and to some extent overhung by the abdomen, are whitish or whitish-yellow above and darkly speckled brown and yellow below, while the legs are longish and definitely banded. If she hung back upwards, the white would betray her, but with the lower side up it is wonderful how inconspicuous she is against the ruddy soil of the karoo. If alarmed she shakes the web until it vibrates with astonishing rapidity, so that she becomes merely a haze; and then she drops to the earth, where she either lies still on her back or clings to a small twig low down, presenting the speckled side to the pursuer, remaining motionless and well hidden.

Yet a third genus of this family may be mentioned. *Cyrtophora* is often found in prickly pear (*Opuntia*) hedges. Here she builds a large geometric web with a dense pyramidal tangle below it, both composed of thread of immense strength. The color varies with these spiders and is of considerable beauty. The abdomen is notched above and projects over the cephalothorax to such an extent that the spider has quite a hunch-backed appearance. Like *Argiope,* she hangs back downwards in the middle of the web, with the pyramidal tangle below her. The threads of her web and tangle are so strong and the prickly pear hedges are at times so densely covered with them that the long stick with which one plucks the sweet ripe fruit often becomes so coated with the powerful strands and so impeded thereby that it cannot be used effectively till cleaned.

Selenops, one of the Clubionidæ, is notable for the lightning-like rapidity of its movements. It is a singularly flat spider of a speckled reddish-brown color, almost exactly like that of the dolerite rocks on the kopjes where it is found. Its legs are long and distinctly banded, giving the whole spider a mottled appearance. When you turn up a stone under which it is, you will find it, clinging back downwards to the lower side. The moment it becomes alarmed it begins to run, sidewise, with a circular motion, first in one direction, then in another, with such astounding rapidity that it becomes just a blur on the stone; and then it flashes sidewise over the edge.

We come now to perhaps the most interesting finds, which concern two of the Lycosidæ and one of the Eresidæ.

It was long held to be an established fact that no two-lunged spiders were trap-door makers; even up to the present, it seems that only a couple of instances had been observed of two-lunged spiders constructing trap-doors to their nests, and these only in the family Lycosidæ (one in South Africa, one in North Africa and one in Russia). But the finds at Hanover have clearly established the trap-door habit as a regular thing in the case of two species of South African Lycosidæ (one of which may or may not be identical with *L. domicola,* the South African instance above referred to) and one species of Eresidæ. I have found many of these nests and have sent specimens to the South African Museum.*

The Lycosidæ are numerous and common throughout South Africa. One finds them in great numbers under stones, in the projecting tube nests and running about the veld. I have found fourteen species here, varying greatly in color and shape, and in size from one eighth of an inch to about an inch in length. Ten of these are new.

Lycosa subvittata has already been mentioned as building the nest with projecting tube, closely resembling that of the new *Hermachastes.* The underground holes of these two nests differ considerably, mainly perhaps in the fact that, whereas that of *Hermachastes* is regularly cylindrical and beautifully white-silk-lined throughout, that of *L. subvittata* is not silk-lined at all but only brown-webbed for about an inch at the top and is not regularly cylindrical. It is not, however, necessary to compare the holes in detail here; the interest is now in connection with the web-lined, irregularly rimmed, projecting tubes, whose essential differences may be briefly noted. The tube of the *Lycosa* is generally shorter, greater in diameter and untidier in appearance than that of the *Hermachastes,* and, while it often slants

* It is remarkable that, while I was laying the facts of the first trap-door *Lycosa* before Dr. Purcell, he should have established at Cape Town the trap-door habit in the case of *Cydrela,* one of the Zodariidæ, another two-lunged family.

and gapes and is not a true cylinder, that of the *Hermachastes* is neat, upright and regularly cylindrical. But the nests frequently occur side by side in the same ground and are almost identical in appearance. For instance, I recently found a nest of the *Lycosa* whose projecting tube was two inches high and so like that of the *Hermachastes* that I had to dig it up to ascertain for certain which spider was the builder.

Thus we have the interesting fact that a true trap-door spider here has abandoned its trap-door making and adopted the projecting tube habit characteristic of a *Lycosa* common to this part of the country; while, on the other hand, we have the equally interesting fact that two species of *Lycosa* have abandoned the habits of their tribe and family and have become regular trap-door makers.

The commoner and smaller of these two trap-door *Lycosæ* is a very alert, often ruddy, spider with banded legs. It makes a hole which is generally a true cylinder and deeper than the hole of *L. subvittata,* and at the opening it always has a door. The doors are thin lids, firm, cup-like in shape, and are attached to the rim of the hole by several almost invisible strands of web. So delicate are these strands (which serve as a hinge, being affixed at several points to the edge of the lid), that I almost invariably move the lid with the point of my knife to ascertain whether it is fixed; for it sometimes comes loose and lies at varying short distances from the mouth of the hole (remaining in use all the time apparently—though of this I am not quite sure). The spider closes the lid in the heat of the day, with the concave, web-lined side down, and opens it late in the afternoon and early in the morning, but so late and so early that it may be said to be open only during the night; though, before the weather became very hot and dry, it was common to see small lids open during the day. Sometimes the lid is attached, on the upper side, to a stone or stick or leaf, but generally it is just covered with earth and lies almost flush with the ground. It is practically undiscoverable when closed. It may be noted that the trap-door *Lycosa* is apparently (perhaps only when young) not wholly nocturnal, and that many have been found under stones, also that the adult male is as much a trap-door maker as the female, and that, when the spider comes from the hole, it opens the door and leaves it lying beside the opening with concave side up—all habits which are certainly not shared by the Ctenizidæ and are apparently peculiar to itself.*

The Lycosidæ are an interesting family in other respects. The female, when about to lay her eggs, makes a neat cup with circular

* I have described the commoner trap-door *Lycosa*, because I have had greater opportunities of observing it; but, as far as my observation goes, the description applies equally to the larger and less common trap-door species.

rim, in which she deposits her eggs, heaped up. She then makes a similar cup which she inverts over them, after which she encloses the eggs between them by soldering them together round the rims. The whole ball of eggs is then spun over with whity-brown silk and attached to the spinners at the end of the abdomen, to be carried about till the young emerge, which crawl out and on to the mother's back, where they remain in a great cluster and are carried about by her for several weeks. She presents an odd spectacle as she rushes about with her numerous progeny on her back.

The Lycosidæ as a family are rovers and do not make regular nests, and this is why the females carry first the egg sacks and then the young about with them. But it is interesting to note that the habit of attaching the egg sack to the spinners (and no doubt also of carrying the young about) persists in the projecting-tube builder and in the trap-door species, although the paramount necessity for doing so apparently no longer exists.

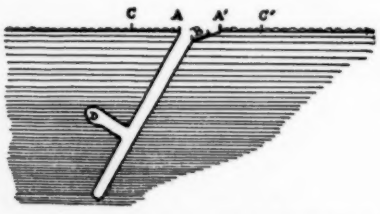
The female *Lycosa* is said to be often curiously dainty about the color of the silk she uses for the inner cup; it is frequently of some bright color, say orange, while the rims are cemented with silk of some other gay color, say bright green. Sometimes she uses as many as four different colors. But, after all this trouble, she has to cover up her gaudy and attractive cocoon with some dull-covered silk, so as not to attract the notice of flies and wasps on the lookout for a nest of fat eggs in which to deposit an egg or two of their own.

My finds in Eresidæ cover five species. Several of them, belonging to *Eresus* and *Dresserus,* found under stones in dense tangles of web, are very slow in their movement and feign death when exposed; one of them is a large creature with an abdomen nearly an inch long and half an inch broad, resembling a huge cattle tick in shape and color (a brownish or bluish slate), even to the puncture-like marks on the back. Of the other species, one is *Stegodyphus;* you may see their dense ball-like yellow nests on the karoo bushes, with powerful strands binding them in all directions. At least one species of *Stegodyphus* is social, but the local form lives solitary or in pairs.

Another is perhaps the most interesting Hanover find. A neighboring Dutch farmer (who carefully obtains the Latin name of every species he brings, and who has been a most useful contributor) asked me if I knew of a small 'licht bruin' (light brown) spider that made a double door. Neither I nor any one else, so far as I know, had ever heard of such a thing. But my friend was not far wrong. Where there are ijzer-kopjes (kopjes of dolerite boulders) there are generally, somewhere on the gentle slopes of the flat at the foot, patches of gritty red sand, composed largely of the disintegrated dolerite. The

sand is loose and desert-like for about two inches in depth, after which it meets sand finer in grain and baked hard. The larger grit lies on the surface. If you look carefully at these patches, you may see a delicate outline, shaped like a butterfly's wings, traced on the red sand, one pair of 'wings' being generally larger than the other, as is the case with a real butterfly. The impression is very beautiful and fairy-like. These 'wings,' which are covered with gritty red sand and lie flush with the surface of the ground, are generally about an inch and a quarter square, the longest measurement being across the front pair. If you insert the blade of your knife under the smaller wings, you may turn the lid over its hinge, which is on the side of the larger pair. This needs to be done carefully, for the lid is limp and delicate and easily doubles up and loses it shape; the operation is somewhat suggestive of tossing a pancake. You expose a smooth bare spot, shaped like the double wings, nearly in the middle of which is the hole.

Though this butterfly lid is about an inch and a quarter square, the hole is hardly, if anything, more than an eighth of an inch in diameter. It is situated almost under the middle of the lid, just below what corresponds to the thorax of the butterfly. The lid is attached to the side of the hole towards the head of the butterfly, and the attachment is restricted to the width of the thorax, leaving the whole outline of the wings free. The hole, which is from two to three inches deep and beautifully brown-webbed throughout, runs straight into the ground at an acute angle under the hinge. The side of the opening opposite the hinge slants, and on the slant, attached to the web lining of the hole, lies a small, loose, felt-like flap.



MEDIAN SECTION OF NEST OF NEW TRAP-DOOR ERESID. *A-A'*, Extent of lid across hole; *C-C'*, Extent of 'wings' on each side of hole; *A*, Where hinge is affixed; *B*, Flaps; *D*, Blind side chamber.

It must be remembered that the large 'butterfly' lid is never raised—indeed, cannot be raised—by the spider; for she is not strong enough, and, if she were, it would double up and lose its shape. So it always remains flat on the ground, covering the hole and the ground for more than half an inch all around it. The spider creeps in and out underneath, as from under a blanket; you can trace its passage by a little wave rippling along under the sand-covered wings.

The flap, I think, has two purposes. First, it affords the little spider a means of easy ingress and egress to the hole under the lid; it is firm and felt-like to give the spider a good hold for her feet over the loose shifting sand, and it is slanting to enable her gradually

to overcome the downward pressure of the large lid; if the hole were perpendicular, the spider would have difficulty in levering herself over the edge against the weight of the lid, and, if the exit were not slanting and there were no flap, the loose, gritty sand would give way under her feet as she strove to get out. The little felt-like flap leads her gradually on to level ground, where she can easily make her way in any direction to the edge of the lid.

Secondly, the flap can, in case of necessity, serve as a make-shift door. If you tear the lid off and wait a little while, you will see the front legs of the spider emerge at *A* and pull at any fragment of hinge left, in order to close the hole temporarily; if she fails at this, she will pull up the flap, which, as I have said, is loose and just long enough to close and conceal the hole admirably. It is interesting to note that the spider always comes up facing *A*, which results in her being pretty well concealed while closing the hole; whereas, if she came up facing *B*, the slant would, to a considerable extent, expose her. This would seem to indicate that the flap is resorted to as a make-shift door only if the spider finds there is not enough web for the purpose left from the torn-off hinge.

Sometimes if you sit and watch an undisturbed nest, you will see the large 'butterfly' lid tremble, and then you will see the points of the little legs appear at the edge as the spider throws out the remains of a small ant or fly or some grains of sand. If you then quickly remove the lid, she will pop round and hide under it on the open ground. If exposed she lies perfectly still with her legs drawn in, feigning death, and may be handled like a dead thing. As she is very much the color of the loose sand, it is quite common to miss her, unless great care be taken.

It will be seen that this wonderful little spider is far ahead of the trap-door *Lycosa* in the complexity of her nest; but we have not yet reached the limit of her intelligence. Often she builds a beautifully webbed blind side-chamber, about half way down the hole, into which she escapes, and which, when the sand is disturbed, collapses over her and enfolds and hides her. I did not find the side chamber till I sought for it carefully. It is a late development, and shows she is no mere brilliant amateur like the *Lycosa*.

The trap-door eresid never, as far as I know, leaves the nest during the day, and certainly never opens the door, but creeps in and out under it, thus always leaving it closed. Neither do the adult males make doors or live under ground. Digging shows females, adult and young in the nests, but males only up to the last molt.

Here again comes a new and very interesting departure on the part of the eresid. The male, which, for all practical purposes, is,

up to the last molt, identical with the female in size, color and shape, becomes quite another being in every respect afterwards. The female and immature males and young have a light brown cephalothorax and legs and a smoky abdomen, the colors being not widely different. But, after the last molt, the male is simply unrecognizable. He emerges a handsome, very alert creature, that runs about openly by day—a habit I think unknown in the Ctenizidæ. His magical change is no less radical in character than in appearance. His cephalothorax and legs are black, except that the front pair of legs, which are considerably elongated, have the fore parts white; his abdomen is black underneath, with a thin band of black round the sides, while the upper part is bright yellow. He moves alertly, often in a series of short rushes, and, if interfered with, does not feign death, like the rest of the eresidæ, but fights promptly and viciously, raising his body in front, lifting his forelegs on high and shaking the white parts angrily at you. To anything near his size he must be a most terrifying object.

Now, why this wonderful change in appearance and habits? Why he has adopted the habit of running about by day, I do not know. But, having done so, I cannot help thinking that his changed appearance and habits may have been evolved as a protection to him. At the time of the year when he appears, a very vicious ant (*Camponotus fulvipilosus*) is common over the veld during the day. The adult male eresid closely resembles this ant in color and style of movement. The ant, like the eresid, has a black head, thorax and legs and a yellow abdomen, and it moves in rushes. The resemblance is so close that, when I first saw the eresid, I took it, for a moment, to be the ant, and when I sent it to Dr. Purcell I described it as 'ant-like.'

No such spider as this eresid was previously known in South Africa. Dr. Purcell says it forms a new genus. I have sent several of its nests *in situ* to Cape Town. This could be done sucessfully only by melting hard paraffin and then pouring it into the sand around the nest, letting it soak up to the lid. Then, when the paraffin had hardened in the sand and bound it together, the nest could be removed in perfect order. The paraffin may be removed from the lid by treating it with warm oil of turpentine. Dr. Purcell will some day give detailed descriptions of all the interesting spiders and other things I have chatted about, with sketches of them and the nests *in situ*, and then we shall be able to call them by the names they will receive from him. Meanwhile I have thought a popular account of some Hanover arachnids might prove interesting.

ZOOLOGY IN AMERICA.

By Professor T. D. A. COCKERELL,
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THE articles in the *North American Review* of January and February on the condition of science in America have naturally aroused a good deal of attention, but no attempt seems to have been made to determine our exact position in any one branch of science. Feeling that the criticisms offered did not apply justly to American zoology, I sought to obtain more exact data upon the subject. Fortunately we have the annual volume of the *Zoological Record,* which enumerates very fully the zoological contributions of each year, omitting only those which are of little or no value. This work, ably edited by Dr. D. Sharp, is published by the Zoological Society of London, and therefore cannot be suspected of enumerating an undue proportion of American articles. As a matter of fact, it errs somewhat in omitting several works published in this country, which cannot easily be obtained in London; while no doubt its list of European writings is very complete.

The latest volume of the *Zoological Record* to hand contains the titles for 1900, including also a small proportion of papers accidentally omitted from previous volumes. I have extracted from this volume the following data:

Division.	Total titles.	American titles.	Per cent. of American titles
General subject,	763	112	14
Mammals,	346	68	19.6
Birds,	580	105	18
Reptiles and Amphibians,	239	33	13
Fishes,	235	32	13.6
Mollusca,	588	148	25
Brachiopods,	48	13	27
Bryozoa,	30	9	30
Crustacea,	192	17	8.8
Arachnida,	131	13	9.9
Myriapoda,	35	1	2.8
Prototracheata,	16	1	6.2
Insects,	1431	235	16
Echinoderms,	370	56	15
Worms,	345	50	14
Cœlenterates,	106	26	24
Sponges,	83	19	21
Protozoa,	167	17	10

I have included among the American titles those published in Europe by residents of America, except when there was reason to believe that they might have been prepared during visits to Europe. I have included papers published in Canada, and one or two from Mexico, but if these were deducted they would not (except in the case of the sponges) materially affect the result. Of course it must be acknowledged that the titles indicate contributions of every size and degree of merit; but as I have looked them over, it has seemed to me that ours were not inferior in quality or size to those of other countries.

The editor of the POPULAR SCIENCE MONTHLY (March, p. 476) has justly remarked that we ought not to expect to equal the rest of the world in our product; and in his opinion if we contribute one seventh we are doing our share. It will be seen from the above list that we actually are contributing approximately this amount in most of the divisions of zoology, while in some groups the proportion is greater. This conclusion agrees well with the impression gained by the writer through his experience of zoology and zoologists both in England and America.

It may be worth while to add some particulars regarding the workers who represent zoology in America to-day.

General Subject.—The list for 1900 includes 82 workers, and the names of Alexander Agassiz, Calvert, Davenport, B. Dean, Eigenmann, Eisen, Gill, Hyatt, Kingsley, Loeb, Minot, H. F. Osborn, Peckham, Pilsbry and Wilson are as familiar to European zoologists as they are to us. Many of the papers both here and in other groups are the work of the great body of University students, prepared under the guidance of leading zoologists, of whom C. B. Davenport, of Chicago, is especially conspicuous for his large following.

Mammalia.—26 workers, of whom J. A. Allen, D. G. Elliott, C. H. Merriam and H. F. Osborn are perhaps the most widely known. The study of the mammals in this country is being carried on with a zeal and industry which finds no parallel in any previous period; and the careful investigation of the geographical races is giving us material of the greatest value in the study of evolution. The credit for this revival is mainly due to Merriam; and the Europeans, who at first ridiculed his methods, are beginning to follow in his footsteps. American mammalogists have also begun to compete vigorously with Europeans in the study of old-world mammals, and G. S. Miller has even described a number of new ones from Europe.

Birds.—66 workers, including J. A. Allen, F. M. Chapman, E. Coues (now dead), R. Ridgway, R. W. Shufeldt and many others well-known in both hemispheres. We have a first-class journal (*The Auk*) devoted to birds, together with a number of minor ones.

Reptiles and Batrachia.—29 workers; the titles including the great work on North American reptiles by the late E. D. Cope. Our principal writer now living is Stejneger of the National Museum.

Fishes.—22 writers; the titles include a part of the great work on the fishes of North America, by Jordan and Evermann. The American fishes have been and are being very thoroughly studied; and Dr. Jordan, with several helpers, is making known the fish-faunæ of Japan and the Hawaiian Islands.

Mollusca.—58 workers, of whom Pilsbry and Dall, in particular, are in the very front rank. H. A. Pilsbry in 1900 published 36 papers, besides three others in cooperation with different workers, and at the same time continued the great Manual of Conchology, which is a monograph of the mollusca of the world. W. H. Dall published 15 papers, and the great value of his work on the bivalves, in particular, is recognized in every country. Other prominent names are those of Beecher, C. T. Simpson, Stearns, Sterki, Verrill, Bush and Whitfield. It must be confessed that there is a lack of good workers on the Pacific coast, though amateur collectors are quite numerous, and are continually discovering wonderful things, which are mostly described by Eastern conchologists.

Tunicata.—There is one paper by Verrill, of Yale, but Professor W. E. Ritter, of the University of California, has this group practically to himself in this country. He is preparing an elaborate work on the numerous species of the Pacific coast, which at present are almost wholly unknown.

Brachiopoda.—Ten workers; the work relates almost entirely to the fossil forms.

Bryozoa.—Eight workers. J. M. Nickles and R. S. Bassler give a synopsis of all the American fossil species, in a work of 663 pages. The principal work on living species is in two papers by Miss Alice Robertson, who has found the Pacific coast prolific in interesting forms.

Crustacea.—Thirteen writers, of whom the two most active are both women —Miss M. J. Rathbun and Miss H. Richardson, of the National Museum.

Arachnida (Spiders, Scorpions, Mites, etc.).—Only about five workers. This group is much neglected in this country, but Nathan Banks, of the Department of Agriculture, is industrious enough to count for two; while the work of the Peckhams on hunting-spiders is not to be forgotten.

Myriapoda (Centipedes).—Only one paper in 1900, and that bibliographic! In former years O. F. Cook has done important work, but his attention is now diverted elsewhere, at least for the time being.

Insects.—107 writers, not counting a considerable number of papers on economic entomology not seen by the editor of the *Zoological Record*. The more prominent names include Ashmead, Banks, Beutenmüller, Casey, Coquillett, Chittenden, Dyar, Fernald, Fox, Bruner, Williston, Holland, Howard, Hulst, Needham, H. Osborn, Schwarz, Scudder, Skinner, J. B. Smith, Strecker, Wheeler and Wickham. Much of the work is descriptive; but the economic work of Howard and his associates is the best in the world, if we may accept the opinion of European entomologists; while the new entomology, which combines the study of form with that of habits, finds admirable exponents in Wheeler and Needham. Dyar's work on the immature stages of insects has been freely used and acknowledged in Europe, and parasitic hymenoptera are sent from London and Paris to Ashmead for identification. G. B. King, the janitor of the court-house at Lawrence, Mass., has, with everything against him, made a reputation as a student of scale-insects, and his cooperation has been sought even in Germany.

Echinoderma (Star-fishes, Crinoids, etc.).—43 workers, much of the work relating to fossil forms. Prominent names are those of Clarke, Loeb, Springer, Vaughan and Verrill. F. Springer, our best authority on crinoids, has been able to produce the most elaborate and careful works in the intervals of a busy life as a lawyer; works which, it may be remarked, are much better known in London than in New Mexico, where he resides.

Worms.—37 writers, but it must be confessed that the papers are mostly of minor importance. Verrill has described a large number of new species. The earthworms and flatworms are greatly in need of more attention.

Cœlenterata.—19 writers. The great work of Nutting on hydroids must be mentioned. Professor Nutting has made this subject very much his own, and was even able to go to Plymouth, England, and discover new forms under the eyes of the English zoologists.

Sponges.—15 writers, three being Canadian.

Protozoa.—15 writers. This group is not receiving a fair share of attention.

So, on the whole, it appears that America is not seriously behind in zoology. Yet, I certainly cannot claim that the position of the science in this country is satisfactory. After all, the real question is, not whether we are doing as much as other people, but whether we are doing what we might, and ought. From this standpoint our deficiencies are serious enough. We are not, as yet, nearly able to cope with the work that lies ready to our hands. When the writer was a boy, he used to read and re-read such works as Wallace's 'Malay Archipelago,' and look forward to the time when he too would travel, and would discover something new. To-day, in New Mexico, he would undertake to find something new every day of the year, if he had no other occupation; and hardly a day passes in the laboratory without the determination of some new fact. But alas, thousands of specimens remain in closed boxes because there is nobody to work upon them; dozens of promising investigations are never undertaken because there is nobody to undertake them. Buildings, apparatus and books are well enough in their way; but the great need is for workers to make use of what is already gathered and ready for use, and to take up the threads of thought which flow from every investigation, and follow them to the end.

While we are seeking to add to the number of workers, something should also be said about their quality. Undoubtedly, there is too much narrowness, and too little general culture, an outward and visible sign of which is the bad Latin published by many of the younger men in the form of zoological names. At the meetings of the American Association for the Advancement of Science, there are sections of zoology, botany, geology, anthropology, etc., all in session simultaneously. The writer found it extremely annoying that he could not be in two or more places at the same time, but very few seemed to see any objection to the arrangement. This indicates limitations which must be regretted, and it is hard to believe that they are inevitable. When the zoologist ceases to know anything about the plants animals eat, or the physical environment in which they live, or even the animals of other groups than his own specialty, the broader ideas of biology will become obscured and evolution itself will cease to be intelligible, just as architecture is nothing to him who studies only single and isolated bricks.

MENTAL AND MORAL HEREDITY IN ROYALTY, IV.

BY DR. FREDERICK ADAMS WOODS,
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SPAIN.

THE early history of its great family is coincident with the history of the rise of Spain's greatness as a nation. Whatever value other factors may have had in producing Spain's glory the presence of the long line of great rulers and warriors must have been one of the greatest. This influence of the great leaders could make itself felt then, even more than now.

Within a short time we have had an example in Lord Roberts of what genius for generalship can accomplish in the turn of events. How much greater impress on his times the great man must have made in those medieval days when the masses knew almost nothing!

I know of no other direct line, except the then reigning one in Portugal, where greatness was maintained for so long a period, nor has there appeared any other than these two dynasties, where vigorous and distinguished blood was so continuously introduced into the stock. Portugal was five times united with the best of the stock of Spain to its evident advantage. Spain took wives three times from Portugal. Two of these, the marriage of Ferdinand II. of Leon (d. 1187) and Ferdinand IV. (d. 1317), were of great benefit. The third was valuable as far as the introduction of Portugal's blood was concerned, but happened to be very unwise, because it brought back again in a double way the cruel traits of Sancho IV. which resulted in producing Pedro 'the Cruel' whose tyrannies amounted almost to madness.

There are a few exceptions among the noble characters, such as the cruel tyrants just referred to, whose traits will be seen to be evidently caused by heredity. Still for *twenty-one* generations in the direct male line of Castile from Sancho II. in the tenth century to Charles Quint, the greatest ruler of his time (d. 1558), there were only four who did not possess a high degree of strength and ability. These were Alfonso IX., Ferdinand IV., John I. of Castile and Ferdinand I. of Aragon.

The first two of these were in the early centuries. John I. of Castile and Ferdinand I. of Aragon were father and son, who lived in the period just before the time of Ferdinand and Isabella.

There were two others, also father and son, who ruled over Castile

at about this same time, who were exceedingly weak. These were John II. and Henry IV. They are not in the direct line under discussion at present, but it is interesting to see that John II. was a grandson of John I. just noted for his weaknesses and the causes of this temporary running out and subsequent rejuvenation in Ferdinand and Isabella will be discussed later.

During the early centuries of Christian Spain the conditions of the times were such that every sovereign was obliged to defend his right to the throne against the jealousies of his family, so that almost constant wars were being waged among the nearest kin and it was practically impossible that several generations of weak and incompetent kings should not have been wrested from the throne. This factor of natural selection undoubtedly did much to insure the strength of the stock.

The long minorities of the sovereigns of Castile and Aragon which occurred time and again during these centuries have always been considered by all historians as one of her greatest misfortunes, leading to intrigues, civil wars and disasters; affairs being put in a healthy condition again only when the king himself was old enough to take things in his own hands.

This and the fact that the country invariably gained ground under good rulers and just as certainly lost under weak ones make it evident how much more important the king was in those days and under those conditions than he has been in England, for instance, where the progress has been due to the people as a whole, especially her aristocracy and upper classes.*

Such a long line of great rulers as this, such an almost unbroken repetition of great physical and mental strength is almost unparalleled, save by Portugal, in all history. If there is much in heredity it must certainly be necessary here to show that the dynasty was continually maintained by the introduction of just such great qualities either from the best part of its own stock or from outside families.

We can discuss twenty marriages in the direct line. The following fourteen can be seen to have introduced stock equally vigorous and able. These fourteen are those of Sancho II., Ferdinand I. of Leon, Alfonso VI., Ferdinand II., Alfonso IX., Ferdinand IV., Alfonso II., Henry III., Don John II. of Aragon, Ferdinand and Isabella, Johanna 'the Mad.' These were scattered along the course and sufficiently account for the perpetuation of the strain. Many of these unions were remarkably good, being well backed on all sides. Of the other six, four were 'obscure,' tending that much to dilute the distinguished qualities.

* Conf. Havelock Ellis, 'Study of British Genius,' POPULAR SCIENCE MONTHLY. (Geniuses have come from the upper classes.)

There was one, the marriage of Alfonso VI., that was distinctly bad, as its average value was incapable as well as vicious. The remaining one introduced mostly poor stock but had a small element of goodness in it. I refer to the marriage of John the First of Castile. Half the pedigree of Henry II. of Transtama and of Alfonso VI. are uncertain for different reasons, as will appear.

Beginning now with the most ancient times let us take up the character of each sovereign and discuss the effect on the breed of blood introduced in the marriage of each. Sancho I. by his courage and mental and physical energy extended his dominion in all directions. He reduced important fortresses on both banks of the Ebro, recovered Rioja and conquered the country from Tudela to Najera, Tarragona and Agreda, and the mountain districts surrounding the sources of the Duero. He was also prudent and pious by nature and his conquests were retained throughout his life by the wisdom of his acts. He died in 994.

Sancho married Urraca, daughter of Ferdinand, belonging to the same stock. They had a son Garcias, called 'the Trembler,' about whom little is known with certainty except that he won battles and apparently he was a successful warrior. The name of 'Trembler' was applied to him because before battle, as he himself put it, 'My body trembles before the danger to which my courage is about to expose it.' The pedigree of his wife, Ximenia, is unknown to me, but from this time on to the present, the descent of the female side can be shown with very satisfactory completeness, and it is these pedigrees which show that qualities were infused in the stock all the way down the line, sufficient to keep up the elements of greatness which never ran out in Spain until the death of the Emperor Charles Quint. After this the worst possible unions were made, and then Spain fell.

Sancho III., who died in 1035, was the son of the 'Trembler.' He must have had great ability for war and government, as he made himself the most powerful prince of his age and country. He married Nunnia, the heiress of Castile, who belonged to a powerful family. He held what he got by inheritance and marriage and even extended his dominions by conquest. He was called 'the Major,' or 'the Great.'

Sancho III. was followed by his son, Ferdinand I. He had high abilities and virtues and made himself the most powerful among many monarchs in Spain. He also is called in history 'the Great.' He married a daughter of Alfonso V. of Leon, a successful soldier and ruler and the son of the valiant Bermudo II., who had won distinction by defeating the Moors.

Ferdinand died in 1065. His son, Alfonso VI., was a great warrior and called 'the Valiant.' Alfonso VI. allied himself to an outside stock. He married a daughter of Robert, Duke of Burgundy. It does not appear that her ancestors were especially distinguished, except that her great-grandfather was Hugh Capet. This can not be classed among the brilliant marriages from the present point of view, as the great qualities are so remote.

Their daughter, Urraca, became queen. She was overbearing and tyrannical in her conduct, with morals of very questionable repute. Her mind was of a light and trivial order, though her ambition was as great as it was unprincipled. 'She left to posterity a character darkened by many crimes and scarcely redeemed by a single virtue.' Her reign, 1109–1126, was fortunately for her people a short one, but she succeeded in keeping the country embroiled in family feuds. (Dunham, 'Spain,' II., 162.) Urraca is the first one in the group who had any such traits. On searching for character of her mother's people, who must have introduced these qualities if they came by heredity, I found them amply accounted for in her grandfather and his mother. Robert, Duke of Burgundy, her grandfather, is described in a short column in the 'Biog. Univer.,' most of which tells of his violent temper. His mother, Constance, was a 'wicked intriguer,' and instigated his revolting from his weak and peace-loving father, King Robert of France. 'Robert (the Duke) had a most violent temper and was capable in the excesses of his anger of the most atrocious extremes.' He showed no application to affairs of state and abandoned the government to cruel and incompetent ministers. Queen Urraca married Raymond, Count of Burgundy. He was not at all distinguished, nor were his family.

The successor of the notorious Queen Urraca was Alfonso VII., who luckily did not repeat his mother's character. Unfortunately for our purpose we cannot be sure of his father, owing to the licentiousness of the Queen. The characteristics of this son and his effect on the country may be well shown by quoting Dunham, 'History of Spain and Portugal,' II., 165:

> Alfonso was no common monarch. Though he lost Portugal and was unable to withstand the genius of his namesake of Aragon, whom he imitated in assuming the imperial title, yet with fewer pretensions, though he is undeserving the exaggerated praises of the national historians, it cannot be denied that he exhibited great firmness in circumstances often very difficult, that he caused his territory to be respected by his Christian neighbors and greatly aggrandized it at the expense of the Mohammedans. His talents, however, were inferior to his ambition, and his moderation to both.

If this Alfonso VII. had wedded only average qualities it is probable that the ancient greatness of the race would have run out, but

what happened is unusual in the story of families. Just at the time when it is weakened by dilution it is again strengthened by the qualities of a great man. The wife of Alfonso was the daughter of Raymond Berengaria III. (d. 1131), Count of Provence, a prudent sovereign who extended his dominions by inheritance, marriage and victory, ruled fifty years and actually carried his conquests across the sea to the shores of Majorica and made successful wars against the Arabs.

The product of this union was Ferdinand II. (1187) of Leon. He was a very able general and had many estimable and generous personal qualities. He made a marriage calculated to perpetuate the great qualities of his stock, that with Urraca, daughter of Alfonso I., the great founder of Portugal, who by consulting the Portugal chart may be seen to be backed up by distinguished fathers and grandfathers and to have himself derived in part his genius for war from the same stock of Spain already discussed, namely, Alfonso VI. 'the Valiant.'

However, Alfonso IX., his son, was without distinguished qualities or virtues. Coming as he does at the union of greatness he must be counted as an exception. Still the genius of the race does not die here. His marriage was one of the very best. His wife, Berengaria, was a famous heroine of Spanish history. She was a truly great and noble woman. Not only in her own qualities, but by her ancestors she must have brought into Spain one of the best strains that any royal person at that time would have been likely to have represented.

She was the daughter of Alfonso VIII. of Castile, rightly called 'the Noble,' whose reign was of great benefit to the country, himself a son of a successful warrior during a short career and grandson of Alfonso VII. already noted for his success. Her grandfather was Henry II., one of England's most vigorous and able kings, according to Hume 'the greatest prince of his time for wisdom, virtue and abilities.'

After the death of Alfonso IX., the throne was taken up by Ferdinand III. his son. 'He was a just, pious, able and paternal ruler, as well as a valiant soldier.' He triumped over the infidels and considerably extended his domains. His wife was a daughter of the Emperor Philip, a vigorous, warlike character, who, being assassinated when only thirty years old, never had an opportunity to display his real abilities. Philip was the son of Frederick Barbarosa, the greatest man and greatest power of his day. Thus a certain amount of able blood was here introduced. Still we see Isaac Angelus in the pedigree, an abusive and incapable ruler. A little more than half of it all was very beneficial, for Frederick was just and wise as well as extremely able, while the Emperor Philip was up to the standard already established here in Spain. The power of the country was considerably increased under Ferdinand III.

Alfonso X., who was the son of Ferdinand III., had abilities and ambition, but was not at all a man suited to the times. He was weak and irresolute, not obeyed by his subordinates, and his reign was far from successful. His time was devoted to learning and the advancement of science, which alone prospered under his rule. He showed a slight amount of cruelty, but this was not conspicuous compared to others in this age and land. There is no question but that Alfonso X. was a man of great intellect.

His character forms an exception and is the only one of the sort I have met with in this region. It is easily accounted for by a combination of ancestral qualities, but such combinations are apparently far from common. He was a poet, scientist and writer, and through his influence learning was greatly advanced. He is said to have been the first royal personage who was also a man of letters. The marriage of Alfonso X. with Violanta undoubtedly served to a certain extent to perpetuate the strength of the stock, for his wife was a daughter of James, the Giant Conqueror of Aragon. Still James with his great abilities as a warrior was violent, cruel, passionate and licentious, and aside from James there is not much distinguished blood in the characteristics of Violanta's pedigree.

We now come to a period of misfortune for christian Spain, and it is interesting to note how closely the welfare of the country follows the character of the sovereigns, how great the impress of the ruler was on his times in those early days in spite of the theoretical representation of the people in the popular branch of the Cortes.

During the reigns of the next two succeeding monarchs, Sancho IV. and Ferdinand IV., the family feuds and lack of a strong and wise ruler affected the country so disastrously that practically anarchy may be said to have prevailed.

Sancho IV. inherited the cruel, passionate disposition of his grandfather, James of Aragon, without his wisdom. His character was also warlike, vigorous and cruel and the only good fruits of his reign were his conquests against the Moors, whom he defeated in Andalusia and even carried his victories into Tarifa, a town in the very furthest extremity of Spain. The marriage Sancho made, when considered on the grounds of perpetuating greatness, may be considered half or more than half good. His queen, Mary, can be seen on the chart to be descended from largely 'obscure' stock, though she was the great-granddaughter of the famous heroine, Berengaria, already mentioned. She was her worthy descendant, for she repeated her character in every particular. Resolute, calm and devoted, she was an astute diplomatist and politician. Whatever successes there were were due largely to her.

Sancho's reign was short, lasting only eleven years. During the life of the queen mother, she exercised, as we have said, a beneficial influence, but after her death the reign of the feeble Ferdinand IV. was one long list of disasters. Some may wonder why Ferdinand should have been so weak, but as many of his immediate ancestors were far from being endowed with vigorous minds, of course he had a chance to get qualities from the poorer of them. He did repeat the cruel, passionate and tyrannical disposition to perfection, but no one appears to have paid any attention to his wishes.

Now again when the mental qualities are threatened we find them brilliantly restored. Constantine, the wife of Ferdinand, was just the one to effect this, as a glance at the chart will show. It is interesting to see Alfonso X., the scholar and poet, again in his grandson Diniz of Portugal, in another country and in another day where probably no influence of environment could come into play. Alfonso was the first and he was the second royal personage who was also a man of letters. The issue of this union was another one of the heroes of old Castile, Alfonso II., who succeeded to the throne in 1312, when only one year old; grew to be a great warrior against the Moors, and taking after his maternal grandmother possessed a large share of prudence and virtue, some of the rarer characteristics of his tribe. As an example of the respect felt for him even by his enemies the following may suffice: The Moorish king of Granada is said to have exclaimed when he heard of Alfonso's death, 'We have lost the best king in the world—one who knew how to honor the worthy, whether friend or foe.' This eulogy is, however, somewhat offset by the evidence that he was extremely cruel at times.

It is now to be noted that there are an unusual number in the pedigree of Alfonso, who have the adjective cruel or some other designation of depravity attached to them. Now a close intermarriage here will undoubtedly give rise to some of those great and valiant qualities, courage, energy and ability in the leadership of men, which were possessed by some, though not by all these royal lords and dames. There is a fair chance that the literary or possibly the pious and amiable qualities may reappear. But such a close intermarriage would be a hazardous one to say the least.

Let us take a survey of the pedigree of Alfonso XI. in order to see what proportionate amount of cruelty and depravity there is in the ancestry of each succeeding generation.

In five degrees of kinship back of Ferdinand II. (d. 1187) we find three such, among the nine persons whose records were obtainable. In the same degree for Alfonso IX. there were only two among the nine. Ferdinand III. (d. 1252), who represents the next genera-

tion, had but three degenerate ancestors among the twelve. In the same degree of kinship for his son Alfonso X., we find five among eighteen. For the next generation (Sancho IV.) the number is two in twelve. Ferdinand IV. (d. 1312), his son, had three in fifteen. So we see that this type of character, though common, was present in Spanish royalty in these early centuries only to the extent of about one in four or five, but in the ancestry of Alfonso XI., on account of a gathering of this cruel type, we find no less than eleven such among the fifteen who could furnish records of any sort. It is simply that about Alfonso XI. there happens to be brought together a number of strains from the four different countries, Aragon, Castile, Hungary and Portugal, each containing an average amount of the qualities in question. However, owing to strange jumping about, which so many characteristics show in the course of hereditary transmission, Alfonso himself shows none of them, but is himself the bridge over which they pass to appear in his son whose actions seemed more like that of a demon than a man—the incarnation of cruelty itself.

A very close intermarriage *was* made by this Alfonso IX. of Castile. His wife was the daughter of Alfonso IV. of Portugal, a brilliant warrior, but withal a cruel tyrant and the one of all rulers in Portugal on whom rests the greatest odium.*

Now let us see what proportion of the passionate and cruel would be found in five degrees of kinship for a child of Alfonso XI. by such a wedlock. Owing to the intermarriage we find but eleven different persons as several names appear twice. There are only three who are free from the characteristics in question, or eight in eleven show the passionate and cruel type. If we take all for six degrees removed we find the number even worse, eleven in fourteen. A son could scarcely escape the worst sort of inheritance, except by the greatest fortune. What did happen was this. Pedro, the only legitimate son of Alfonso XI., known in all history as 'Pedro the Cruel,' amused himself in some such ways as this. He imprisoned and foully treated his first wife, Blanche of Bourbon, and during the first part of his reign had many noblemen, among others Don Juan, his cousin, executed in his presence. Once, it is stated, in the presence of the ladies of the court he commanded a number of gentlemen to be butchered until the Queen, his mother, fell into a dead faint in company with most of the ladies present. "He then caused to be murdered his own aunt, Dona Leonora of Aragon, mother of the above Don Juan, for nothing except that Aragon would not make peace with him—'being compelled to get Moors to do the job, as no Castilian could be induced to undertake it,' says King Pedro IV. of Aragon in his memoirs. A certain priest coming before

* McMurdo's 'History Portugal,' three volumes, London, 1899.

him to say that St. Domingo had appeared to him in a dream and counselled him to tell the king that he would meet his death at the hands of his brother, Henry Pedro insisted that the priest must have been prompted by Don Henry himself, and so ordered the poor dreamer to be burnt alive. One lady, Urraca Osorio, for refusing his address, was burnt alive in the market place of Seville. Another disfigured herself in order to escape his attentions. "He was as devoid of generosity as of pity, as reckless of the truth as of life, as greedy of gain as of blood—a false knight, a perjured husband, a brutal son."*

Thus Pedro 'the Cruel' is amply accounted for by heredity alone, without bringing in the question of the inheritance of any acquired characters, and it does not seem that this brutality could be the result of the environment in which he lived since before his day when times were even rougher we find so many kings and queens possessing every virtue. There were never any before as bad as Pedro nor were there any, on grounds of heredity alone, as likely to be so. It is interesting to note that he was the great-great-grandfather of Richard III. of England, with whom he is often compared. Pedro's actions cost him the loss of most of his subjects, and finally his life at the hands of his bastard brother, Henry, who had somewhat the same characteristics though in a lesser degree.

Henry established a new line under the title of Henry II. His own origin was, probably, without distinction on his mother's side, and this is one of the four successive unions now to be discussed which can not in any way be used to illustrate the perpetuation of genius. It is also at this time that we find four incompetent rulers, three of whom are described as imbeciles. This is very significant, though I do not see that the imbecility of John I. of Castile is at all properly accounted for by heredity. Mere weakness, cruelty and licentiousness might be well expected, but not imbecility in the medical sense of the word, and I do not know that this medical sense is implied by the historians when using this term in connection with these persons. The origin of the well-known insanity in the Spanish and Austrian houses, perpetuated over thirteen generations and involving more than a score of individuals, is a very interesting question. It cannot be traced with certainty prior to Isabella, the Queen of John II. of Castile. This Isabella was out and out insane, according to the celebrated English alienist, Ireland,† and from her, onward, the insanity passed along in one form or another by the very intermarriages which their pride and political motives caused them to arrange, with the intended idea of making permanent their world power, but with the inevitable result of losing that same prestige by placing it in the

* Watts' 'The Christian Recovery of Spain.'

† Ireland, 'Blot on the Brain.'

hands of the unfortunate children whose inheritance was necessarily mental weakness as the result of such unwise wedlocks.

Without taking up the characters separately we need only look at the chart to get a clear idea of the predetermined cause which lead to the peculiar characters who were foremost during this epoch and to see how perfectly natural it was that there should have been some exhibiting the most depraved characteristics while others, like Ferdinand and Isabella, were fortunate enough to inherit the genius which we see is likewise present in a conspicuous degree. The chart shows that Isabella might be expected to be greater than Ferdinand. She had five elements of genius in her pedigree, being through intermarriage twice the great-granddaughter of John of Gaunt, Duke of Lancaster, one of the great men of his day, and John the Great of Portugal appears twice in the pedigree for the same reason. She was also the granddaughter of Henry III. of Castile, who was a model of all that a king should be. Both Ferdinand and Isabella possessed high ability and character, as can be fully confirmed by consulting any history of the times. They were married through personal choice of the queen, as she appreciated in Ferdinand a man worthy of her love. Nothing could be better for the welfare of the country than that two such able rulers should sit upon the throne at once. But Ferdinand was her second cousin and the descendant of weak or perfidious rulers.

We now see that the children of this union have two estimable parents but they have a remarkably bad lot of grandparents, and back of this we find the worst weaknesses in some while in others is much ability of a very high sort. We should not expect a child to be ordinary. On the other hand the most extraordinary is only to be expected. The two descendants whom we have here to consider are Joanna and her son, the Emperor Charles Quint. The former got the insanity and imbecility, the latter the genius and a touch of the neurosis as well. Every one in this region of the chart fills in a link in a way to be expected and is readily and perfectly explained.

The pedigree of Philip the Fair, who married this mad Joanna, contains the great fighting qualities of the old kings, tremendous energy, and great ruling functions without a bit of the insanity and weaknesses shown in Castile and Leon. This was the famous marriage that placed the Hapsburgs on the highest pinnacle of power—a marriage almost certain to produce genius and as certain to produce some descendants whose heritage would be imbecility or weakness, or whose ambition would only lead them to mad extremes. Both the genius and the insanity appear quite as we should expect, and it is to be noted that the neuroses are now seen to appear for the first

time in the Hapsburgs, since they are introduced into this family through the blood of Castile and Leon; and furthermore these afflictions appear at once. From this time onward, insanity is rampant. Why should it have remained so and not have diminished through reversion to the mean? Let us look at the subsequent marriages.

The Emperor Charles V. married Isabella, a daughter of Emanuel the First of Portugal, a mediocre king, and an inbred descendant of the great Portugal house. Her mother was a sister of the mad Joanna and granddaughter of John the imbecile, and Isabella, the insane. So this may be called a pretty close intermarriage, as well as an unadvisable one. The Emperor himself was somewhat eccentric. He was cruel as well as inordinately ambitious, but he was withal a great ruler. Towards the latter part of his life he was especially subject to melancholia. The effect of this unwise marriage was of course to perpetuate these traits. We shall see under Austria how the evil qualities were much less conspicuous and how the influence of outside stock made itself felt in counteracting these undesirable perversions. The descendants bred true to kind, and in all regions of the chart we find the vicious qualities appearing in places where we should most expect them, that is, in places where the intermarriages were closest.

It is a matter of common belief that intermarriage alone is a cause of insanity, therefore, it is worth while to consider that here it is merely perpetuating what already exists and cannot be considered the cause of its beginning. In a later chapter this question will be more fully discussed. It was not yet time for the intellectual qualities to entirely disappear, for Charles Quint had two descendants who are celebrated historical characters. These were Don John of Austria and Alexandre Farnese, both of whom so distinguished themselves by virtue of their great abilities that abundant material can be found in any biographical dictionary to confirm the belief that these men were geniuses. His grandson, Albert Archduke of Austria and Governor of the Netherlands (son of Maximilian II.), was a man of high though not the highest talents. There are three others worth mentioning in this connection. The Archduke Charles, his great-grandson, is spoken of in this way:

> He died in the twenty-sixth year of his age of a malignant fever. He was deeply regretted by the nation, being universally considered a prince of extraordinary merit and endowments . . . active and ambitious spirit.*

The Cardinal Ferdinand, his brother, was a man of equal mark and merit, who as Governor of the Netherlands there warded off Spain's impending disasters until his untimely death brought a great

* Dunlop, 'Mem. Spain.'

loss upon his country. He is spoken of in the highest terms by all historians, especially for his bravery, prudence and magnanimity.* Don John, a natural son of Philip IV., also was the possessor of great qualities.

It is noteworthy that three of these six were illegitimate, and that the greatest, Alexandre Farnese and Don John, were of these three. It seems probable that owing to the extremely high-strung and unstable condition of nearly all the members of the family, a union with an entirely different class of people would be of advantage to the health and balance of mind. It was not so much that ability was needed as a toning down of the excessiveness that had been manifesting itself in so many ways.

Of these mentioned, one was a son, two were grandsons, two were great-grandsons and one was a great-great-grandson. The most eminent were the closest related, and it is probable that the number of more distant relationship would not have been so large (as in the case of Galton's tables) but for the close intermarriages, giving the genius a chance to be further perpetuated than would ordinarily have been the case.

The kings of Spain never again had anything of the renowned abilities of Isabella, Charles, or the celebrated warriors of early days like Alfonso VI. (1126), James I. of Aragon, or John the Great of Portugal. It might have been that some of the eldest sons should have inherited the great qualities instead of little ones, but Spain may be said to have been unlucky in this, and as the next three, Philip II., III. and IV., did not get the best, in each succeeding generation the chances of its reappearing become more and more dim until the probabilities of a reversion were entirely unlikely.

Let us now notice the neuroses in this same region. The amount of insanity, or at least marked deviation from the normal, should be strikingly conspicuous owing to the intermarriages. It is so. Philip II. is described in this way by Motley.

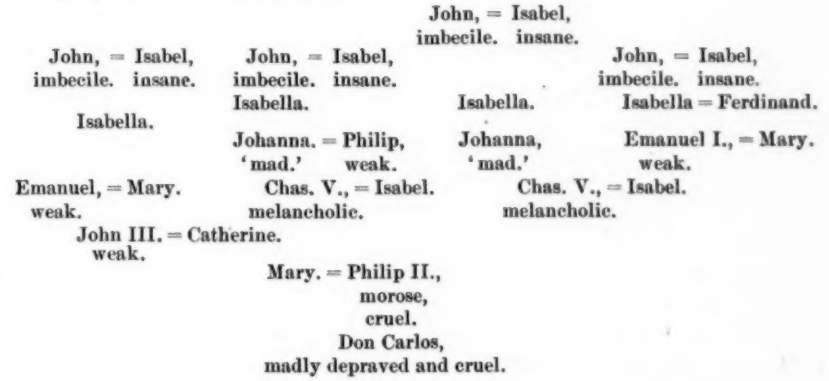
> He was believed to be the reverse of the Emperor (his father). Charles sought great enterprises, Philip would avoid them. . . . The son was reserved, cautious, suspicious of all men and capable of sacrificing a realm from hesitation and timidity. The father had a genius for action, the son a predeliction for repose. His talents were in truth very much below mediocrity. A petty passion for contemptible details characterized him from youth . . . diligent with great ambition. . . . He was grossly licentious and cruel.†

Philip II. evidently took after his grandmother, Joanna 'the Mad,' who was weak and melancholic, and perhaps also his grandfather, the feeble Philip 'the Fair' of Austria. He did not resemble either his

* Dunlop, 'Mem. Sp.,' I., 183, also Hume's 'Spain.'
† Motley's 'Rise Dutch Rep.,' Vol. I., p. 142.

father or mother. Both of Philip's marriages were from the biological point of view extremely unwise, the first being worse than the second, as Mary was a daughter of John III. of Portugal, who was weak and bigoted, in fact, a man much like Philip himself. Philip's wife was doubly related to him, being both first and second cousin, and this relation coming by way of the insane ancestors. So what wonder that the child of this union, Don Carlos, should have been one of the most despicable and unfortunate specimens of humanity in modern history?

The following pedigree of Don Carlos shows his chances of inheriting the inbred neurosis:



Here if there had been many children instead of one I should say that in a rough way extreme degeneration would be likely to be present in somewhat more than half the number. It is significant to notice that the two worst characters in all modern royalty, Don Carlos and Peter 'the Cruel,' are also the two who have the worst pedigrees.

Don Carlos, it will be observed, though a great-grandson of Joanna 'the Mad' and Philip 'the Weak,' has almost exactly the same blood. Ferdinand and Isabella extend right across the chart. Emanuel I. takes his origin from a root almost identical with both Ferdinand and Isabella, and this root we have seen is the reign in which the insanity must have originated.

I do not see how Philip could have planned it better if he had wanted this son whom he really so much despised.

The son by Philip's only other productive marriage was Philip III. Here again we have a close inbreeding, though through a somewhat better route. Anne was his own niece and even more closely related than a niece, as her father was Philip's own cousin. The only outside blood was distant, by Ladislaus, King of Hungary. This blood was presumably healthy though not distinguished. Philip was a man of very low mental calibre (about grade 2). Hume says he was not

a fool, though Prescott calls him the imbecile grandson of Charles V. The melancholic tendency appeared in him, though not to the extent of insanity. Ireland sums the whole situation up thus: "Philip was a man of feeble and indolent character, governed by worthless favorites. The power of Spain declined as rapidly as it had risen."*

This is the same story over again in the history of Spain. We find the condition of the country reflecting the character and strength of the monarch. Many times through the course of the centuries she had been blessed apparently through heredity by great and able rulers and her course had been hampered only here and there by the presence of a weak one; but all this from the great Emperor Charles's day onward was to be just reversed by the same almost unerring law of descent. I do not mean that a weak monarch might not exceptionally, even in those early days, reign over a glorious period. The greatness of Portugal lasted through the reigns of two weak sovereigns, Emanuel I. and John III., though the germs of decay were clearly at work. Likewise Spain's glory had its greatest outward manifestation of splendor in the time of Philip II. whose acts were nearly all injudicious. The increment of one period made itself felt in a later. Still in general the countries prospered only under the great leaders.

Philip was not as bad as Carlos, nor was his pedigree quite as hopeless. The roots from which he sprung were practically all from the weak John II. of Castile and Isabella the insane. In this he is like Carlos. However, it is to be noted that three of his immediate ancestors were excellent characters, though not especially gifted. These are represented as such on the chart. Ferdinand I. and Maximillian II. will be taken up under Austria.

The marriage of Philip III. was no more fortunate. His queen was the daughter of Charles, Duke of Styria, who was evidently not the possessor of great talents, as I have never been able to find a reference to his character or achievements. He was the son of the same Ferdinand I. Charles's wife was of 'obscure' origin. Thus the neurosis was perpetuated and furthermore the genius was not maintained. However, very high ability still cropped out in two of Philip the Third's many children. These were Charles and Ferdinand, already treated. But unfortunately the crown did not fall to either of them, and so we have an artificial election of the worst. The reign of Philip IV., who became king, was a period of great misfortune. His only good qualities were his love of art and literature, and perhaps his best bequests to the world are the famous portraits of himself and family painted by the great Velasquez.

Besides being weak and foolish he was 'far inferior to his prede-

* Ireland, 'Blot on the Brain,' p. 156.

cessor in purity of life.' "Spain might still have regained the lofty station she once held in the rank of kingdoms if at the succession of Philip IV. a wise and energetic monarch had ascended the throne."*

By his marriage with his niece, Maria Anne, he succeeded in having two degenerates, Prosper, who had convulsive fits from his birth and died young, and Charles II., who became king.

Charles was the last of the Spanish-Austria line and in him all its weaknesses were combined. Feeble in mind and body, he was grossly superstitious and so ignorant that he did not know the names of some of his own towns and provinces.†

By his marriage with Elizabeth, who was a great-granddaughter of Ferdinand I., and consequently partially of the same tainted stock, Philip IV. had one licentious weakling out of three children. This child, Don Balthaza, the subject of the famous Velasquez recently acquired by the Boston Museum of Fine Arts, was so dissipated that he brought himself to his grave before he had reached his seventeenth year.‡ Another of the three, Maria Theresa, who married Louis XIV., was extremely stupid.

Charles V. did not have any posterity and the war of the Spanish succession deluged Europe with blood, but the Austrian House did not reach its end through any sterility caused by inbreeding, for in spite of the inbreeding it is noteworthy that they had large families, quite as large as elsewhere. Many of the children died in infancy, but the wives were not sterile. It can not be argued that inbreeding was a cause of the large percentages of early deaths, since we have also to deal with the question of insanity and neuroses. All sorts of mental and physical defects, such as are known to be frequently found in families with an insane diathesis, may have been the cause.

This completes the study of what may be conveniently classified as two groups. First (*a*) the old Castile, Leon and Aragon, families; second, (*b*) the Hapsburgs in Spain. Let us first review the characteristics of the former. This subgroup (*a*) contains 97 names. The character and ability of the 97 have been found in 63 cases with sufficient fullness for the purpose in hand. The other 34 must be marked 'obscure.' They are valuable in a negative way. There were about 39 of the total who had very marked ability, evidently considerably above the average of kings and queens and such as should place them in grades 7 to 10 of the standard here used. This percentage of over one in three is a high one, but the most striking fact is that out of the thirty actual sovereigns on the thrones of Castile, Leon and Aragon, no less than twenty-two are of this group. This

* Dunlop, 'Mem. Spain,' Vol. I., p. 23.

† Young, 'Hist. Netherlands,' p. 611.

‡ Dunlop, 'Mems. Spain,' Vol. I., p. 378

I attribute in part to the constant struggle between the rival families, between brothers of the same family and other close relatives, in their jealous greed for power and domain, thus keeping up a struggle for existence, capable of showing itself in results, and partly to fortuitous chance endowing the heir to the throne with the qualities of the stronger rather than the weaker of his ancestry. The number of weak or indolent is correspondingly small, though high temper, jealousy and ambition are present in nearly all.

I find about six persons to whom the terms feeble, characterless and indolent, are applied. Two of these, Andrew II., King of Hungary, and Ferdinand IV., of Castile, are apart from the others. The remaining four are very closely related, being father, son, nephew and his son. These are John I., John II., Henry IV. of Castile and Ferdinand I. of Aragon.

The family had already existed twelve generations before these characteristics appeared in it. In the tenth generation one of the greatest names is found in Ferdinand IV., and even in the nineteenth and twenty-first generations some of the best and most vigorous and ambitious appear in Ferdinand, Isabella and the Emperor Charles, all of whom were the descendants of the privileged few with a pedigree practically entirely of this sort extending back through more than twenty generations on all sides, and including many thousands of nobles titles.

These names which close the group are as great as those which opened it. How can this be if the assumption of rank and power is to lead to degeneration? It may be argued that the necessity for action in these times of incessant strife obliged the individuals to be energetic and so the characters were the product of their times, but we have seen that the selection alone would produce this. Furthermore, against the environment explanation we must remember the great number of able and vigorous men who appear much later in history in other countries and the descendants of forty instead of twenty generations of blue-bloods. The modern Saxe-Coburg-Gotha chart is almost entirely free from weaknesses and indolence.

The insanity apparently starts in Peter the Cruel. We have seen how his character might well have been the result of a combination of a large number of cruel persons. This insanity continually reappeared in Spain, where one finds it most rampant. It occasionally appeared in Austria, where it was less often introduced. It probably was also the origin of the Plantagenet neurosis, the full history of which I have not yet had time to study with any completeness.

THE SIZE OF ALASKA.

By GEORGE B. HOLLISTER,
U. S. GEOLOGICAL SURVEY.

ALASKA, as a portion of our national domain, is at this time justly demanding our interested attention. Its marvelous resources and their probable rapid development are already bringing many to its shores, and will undoubtedly attract many more; hence, new facts regarding it, or old facts placed in a new light, must be of general interest. For many reasons, but chiefly because of its distance from the United States and the present difficulties of travel in its interior the size of the territory has been but little understood and probably much underestimated.

We know that its area has been stated by the geographers to be about 600,000 square miles, but unrelated figures, after all, give to

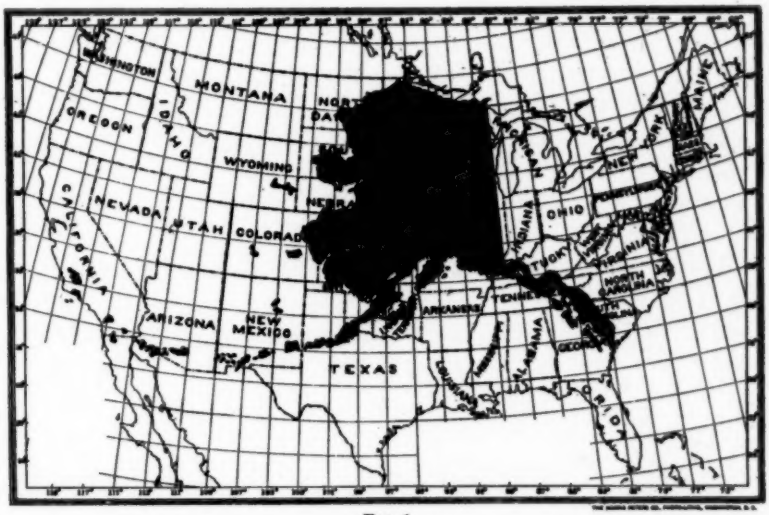


FIG. 1.

the average mind but vague ideas of the extent of territory. When it is said that Alaska has one fifth the area of the whole United States, one begins to have a more intelligent conception of its size, for in a general way the average American readily forms a fairly accurate mental picture of the broad size relations of his country. But so great is the extent of the United States and so difficult is it to judge accurately of the relations of geographical measurements that even this is

not a satisfactory comparison. For this reason our practical knowledge would not be much benefited were it stated that the area of Alaska is equal to that of three and one quarter Californias, or ten Iowas, or one hundred and twenty-seven and one half Connecticuts. But if it were possible to take the whole territory of Alaska and its adjoining islands and place them upon the portion of North America occupied by the United States it would be a simple thing to show exactly what the relations of these great possessions to our own country are. Just this, in effect, has been done, as the accompanying illustration shows. The chart was prepared by Mr. Alfred H. Brooks, geologist of the U. S. Geological Survey, in charge of the government work of exploration and geological investigation of the territory, who has drawn upon the map of the United States an outline of Alaska. The scale used in both instances is the same, and the result is most interesting. When Point Barrow, the most northerly extremity of Alaska, is placed upon the Canadian border in northern Minnesota, Mt. St. Elias falls near the Ohio River between western Kentucky and Indiana, and the main portion of the territory covers almost the entire area of the Great Plains and Mississippi Valley as far south as Arkansas. The extreme southeasterly portion of the narrow strip of Alaska, upon which Sitka and Juneau are situated, would extend to the Atlantic Ocean at Georgia; the celebrated Nome District would fall in western South Dakota near the Wyoming line, and the most westerly of the Aleutian Island group would lie upon the Pacific coast line near Los Angeles; the intermediate islands touching the Mexican border in Arizona and New Mexico. In other words, the territory of Alaska is sufficient in geographical extent to reach from the Atlantic to the Pacific and from Canada to Mexico. Placed in this position on the United States Alaska would cover, in whole or in part, twenty-three states and territories, and the western third of Lake Superior.

DISCUSSION AND CORRESPONDENCE.

A BIOGRAPHICAL INDEX OF THE MEN OF SCIENCE OF THE UNITED STATES.

AT the request of the executive committee of the Carnegie Institution I am compiling a biographical index of the men of science of the United States. It is intended in the first instance for the use of the institution, but it will probably also be published. The index should include all those who have carried on research in science, the term, however, being used in its narrower sense so as not to include on the one hand philology, history, economics, etc., nor on the other hand medicine, engineering, education, etc., except in so far as these applied sciences may contribute to pure science.

During the summer I sent to a large list of names (some 8,000) a blank with the request that it be filled in and returned. The blank asked more especially for information in regard to the scientific career and work of those to whom it was addressed. The response has been very gratifying, but as the circular was sent with a one cent stamp, it did not reach immediately some of those absent from home during the summer holidays. I shall be glad if those who have received this blank will fill it in and return it to me. It will be necessary to send a second request by letter postage to those who have not replied; but time and money will be saved if those who see this note will be so kind as to fill in and return the blank in case they have not already done so.

The list of those to whom the blank was sent was compiled with care, and includes the members of the scientific societies of the United States requiring research as a qualification (some fifty), the scientific staffs of the leading institutions of learning (some seventy), the scientific men included in 'Who's Who in America' and others whose names were accessible. There are, however, many connected with smaller institutions and in private life, not members of scientific societies, who have published research work of value, and I shall be glad to have assistance in securing their names and addresses. I shall be under obligations to any readers of this journal who have carried on research in the sciences, but who have not received the blank, if they will send me their names; and I shall be glad to receive the names and addresses of any who have carried on research, but whose names would not be discovered from the lists of societies, larger institutions of learning and existing biographical dictionaries.

J. MCKEEN CATTELL.
GARRISON-ON-HUDSON, N. Y.

THE PROGRESS OF SCIENCE.

THE SMITHSONIAN INSTITUTION AND ITS DEPENDENCIES.

THE lamented death of Major Powell should not affect the work of the two great national institutions for the creation and organization of which he was chiefly responsible. Powell resigned the directorship of the U. S. Geological Survey in 1894, leaving it one of the strongest scientific agencies of the government. During the later years of his life when his health began to fail, he entrusted the administration of the Bureau of American Ethnology to his principal assistant, Dr. W J McGee, who was given the title 'ethnologist in charge.' Such divided control is not usually advisable, but in this case there was perfect sympathy and cooperation, and Major Powell appeared to have provided with remarkable foresight for the continuation of the work that he had inaugurated and successfully conducted. It is a serious blow to scientific work under the government and to anthropology in the country that Powell's plans have failed.

Many do not know that three of the important scientific institutions supported by the government are administered by the Smithsonian Institution—namely, the National Museum, the National Zoological Park and the Bureau of American Ethnology. The two first secretaries of the Smithsonian, Henry and Baird, were always ready to undertake plans for 'the increase and diffusion of knowledge among men,' in accordance with the terms of Smithson's remarkable bequest. When a scientific movement had been inaugurated they were glad to place it under the conditions most favorable to its development. It suffices to mention the weather reports inaugurated by Henry and now conducted as the Weather Bureau under the Department of Agriculture, and the movement for fisheries inaugurated by Baird, which has become the Fish Commission. In accordance with this policy, Henry recommended the separation of the National Museum from the Smithsonian Institution, believing that it would be more liberally supported under direct governmental control and that the institution would be freed for work that it only could do.

The policy of his predecessors has not been followed by the present secretary of the institution. It is generally believed that the miserable building of the museum would long ago have been replaced by a building such as is possessed by the American Museum of Natural History in New York City and that the collections would be far larger and more symmetrical than they are if the museum had been handed over to the Department of Agriculture. The development of the museum under adverse conditions was largely due to the late G. Brown Goode. On the occasion of his death some six years ago, however, the secretary of the institution did not for some time appoint a successor at the museum, but divided the work among three head curators. Now, on the occasion of the death of Major Powell, the secretary has given to one of these curators the directorship of the Bureau of American Ethnology, not, however, giving him the title of 'director,' but that of 'chief,' thus lessening the importance of the position, while subordinating it to the National Museum and to the secretary of the institution. If this were done in order that the secretary might take more direct interest in the work of the

bureau it might be excused, but as he is known to have shown lack of sympathy with its work in the past, it is naturally supposed that he purposes to subordinate the research work of the bureau to the collections of the museum. It seems extraordinary that a bureau supported by an appropriation from Congress should be entirely at the mercy of one who is not an officer of the government and whose action is apparently exempt from any control. The office of director of the Bureau of American Ethnology, though not created by Congress, has been officially acknowledged by an act of Congress, and it does not seem possible that this office can be summarily abolished or that Congress will agree to the subversion of the bureau. It is not likely that a physicist, supposed not to be in full sympathy with work in natural history, will be allowed to dictate the policy of the National Museum, the National Zoological Park and the Bureau of American Ethnology, when it is known that his actions are almost unanimously disapproved by the scientific men of the country. It is obvious that the situation is complicated rather than relieved by the fact that the secretary of the Smithsonian Institution and those whom he has placed in charge of its dependencies are men of eminent scientific attainments and of the highest character.

It is probable that the result will be the separation of these institutions from the Smithsonian Institution. The National Zoological Park will then be made not merely a toy for the entertainment of children, but also a laboratory for scientific work. The National Museum will no longer be regarded chiefly as one of the sights for visitors to Washington, but will take its place with the museums of the British, French and German governments. The Bureau of Ethnology will extend its work, so that it will include in its scope the native tribes of our newly acquired possessions, the negroes, the immigrant races and the general ethnology of the people, affording information of the utmost importance for their government. The president of the United States recommended in his first message to congress that the scientific bureaus be concentrated under the Department of Agriculture, and it is to be hoped that Congress will find time to consider the question in the approaching session. If this occurs there is no question but that the institutions supported by the government but administered by the Smithsonian Institution will be transferred to the Department of Agriculture. This will not only give these institutions scope for free development, but will release the Smithsonian Institution from irksome official duties, and will permit it to carry forward more effectively its mission for the increase and diffusion of knowledge.

THE UNIVERSITY PRESIDENT.

FOUR important institutions of learning have witnessed the inauguration of new administrations during the past month. Hereafter we must speak of President Wilson of Princeton, President Swain of Swarthmore, President James of Northwestern and Chancellor Strong of Kansas. Dr. Carroll D. Wright has also been installed as president of the collegiate department of Clark University. The duties of a university president are so comprehensive and diverse that it is not surprising that men of varying qualifications and types of character are chosen. To run back ten years we find a professor of Semitics at Chicago, a zoologist at Stanford, a philosopher at Cornell, a man of business at Pennsylvania, a student of Greek at California, a clergyman at Brown, an economist at Yale, a chemical investigator at Johns Hopkins, a student of education at Columbia and so on. Those acquainted with these men and even those who have merely seen them together on the stage at one of the inaugural exercises or

other university functions that have become so numerous in recent years realize that their types of character are as various as their interests. As evolution progresses by variation and survival of the fit we may look for rapid progress in educational administration from the great diversity of college presidents presented for natural selection.

The most striking contrast is evident between the inaugural addresses of the new presidents of Northwestern and Princeton. The Salvation Army captain and the Jesuit priest are not more unlike. President James is full of the spirit of democracy and progress; he overflows with the popularization of the university, technical training, coeducation, university extension, correspondence schools and the like. President Wilson dreads all these things. "In order to learn," he tells us, "men must for a little while withdraw from action, must seek some quiet place of remove from the bustle of affairs." "I believe general training, with no particular occupation in view, to be the very heart and essence of university training." President Wilson here obviously confuses the college with the university, due doubtless to the fact that the college of New Jersey has altered its name to Princeton University, without a corresponding extension of its functions. Whether or not a college for liberal culture, student life and athletics should be maintained apart from a university is still a disputed question. President Hadley in his address at the installation of Chancellor Strong, seems to have struck the correct note when he said:

> We should seek for the solution of our university problems, not in the enforced addition of a German course to an English one, but in a combination of the English spirit with the German organization; so that we can teach professional studies without teaching the spirit of professionalism. . . . If our educators can manage to combine the framework of the German university with the spirit of the English university, or of the old-fashioned American college, they will economize the time of the student without sacrificing the educational result to be achieved. They will give to the community, for whose benefit they exist, the trained experts on which the community insists; and they will at the same time provide for the maintenance of that healthful public spirit in the individual and public sentiment in the body politic on which it may sometimes perhaps not so strongly insist, but which it needs all the more for its permanent continuance and prosperity.

THE JOHN FRITZ MEDAL.

THE four great American engineering societies—The American Society of Civil Engineers, The American Institute of Mining Engineers, The American Society of Mechanical Engineers and The American Institute of Electrical Engineers—have united to establish a medal in honor of John Fritz, the well-known iron master and mechanical engineer, who has at Bethlehem done so much to forward the engineering interests of the country. Subscriptions of $10 were invited from the members of these societies and the sum of $6,000 was contributed. The design has been executed by Mr. Victor Brenner, and a gold medal will be awarded each year for achievement in the industrial arts and sciences by a joint committee of the societies mentioned above, and it is expected that this medal will have the same representative character as is held by the Bessemer medal conferred by the British Iron and Steel Institution. In addition to the establishment of this medal, a dinner was held in New York City on October 31 to celebrate Mr. Fritz's eightieth birthday. The arrangements were made by the same societies and five hundred members and guests were present. Speeches were made by representatives of the different societies and others, and Mr. Fritz responded. We reproduce the frontispiece of the program—a portrait of Mr. Fritz, the industries with which he has been identified and his signature.

GASES IN INTERPLANETARY SPACE.

THE question of whether interplanetary and interstellar space is a vacuum or contains matter in an exceedingly attenuated form is an interesting problem, and one upon which there has long been much speculation. On the one hand the planets give no evidence of an impeding friction, but on the other hand the evidence of such friction in the case of certain comets seems possible. When the earth's atmosphere was supposed to consist solely of oxygen, nitrogen and carbon dioxid, it appeared very improbable that these should pass to any considerable distance away from the surface of the earth, but, with the more recent knowledge of the constituents of the atmosphere, this thesis seems less certain. The discovery of argon by Rayleigh and Ramsay has led to the further discovery of the presence of helium, neon, krypton and xenon, which have enriched chemistry with a new type of chemical element, having no affinity, forming no compounds, and being, as far as has yet been found, perfectly inert. At the same time comes the knowledge that no inconsiderable quantity of hydrogen is a constant constituent of the atmosphere. This has been abundantly proved by Gautier, by Dewar and by Ramsay. Of these gases, hydrogen is the lightest of terrestrially known elements, but helium is not far behind it, and has not yet been changed from its gaseous form to that of a liquid. The methods which have availed to condense hydrogen to a liquid have thus far failed with helium. Turning to the chemistry of the sun, the spectroscope shows the presence of an atmosphere largely of hydrogen, but helium is also present, extending far out from the central mass of the sun. The same instrument reveals lines indicating other elements at still greater heights in the sun's atmosphere, among them one which has been named coronium. From its position far away from the surface of the sun, it seems probable that coronium has a density far less than that of even hydrogen. Again, the evidence of the spectroscope upon the lightest constituents of our atmosphere points to the presence of other gases than helium and hydrogen, and this is reinforced by what the same instrument shows of the aurora. The latter appears to be an electric phenomenon, concerned with elements at least in part now unknown to us, and at a height above the surface of the earth at which it was long supposed there could be no appreciable atmosphere.

It thus appears that the upper strata, both of the sun and of the earth, consist of the lighter constituents which are largely removed from the lower atmosphere by their lightness, and no limit can be placed upon the distance to which these elements would travel from sun or earth into interplanetary space. What is true of sun and earth is doubtless true also of other planets and other suns, and it seems not impossible that even interstellar space may contain these and similar gases in an almost infinitely attenuated condition. What the condition of these gases may be at the temperature of interstellar space, which cannot be far removed from absolute zero, it is difficult to say. On the one hand, at such a temperature they might be expected to be solids, but, on the other hand, the particles would be relatively so few and far apart from each other that they would have the properties of a gas. The great advance in our knowledge of these fields during the last few years gives promise of much new light in the near future.

THE DESTRUCTION OF FORESTS BY FIRE.

A PRESS bulletin from the Bureau of Forestry gives an abstract of a forthcoming paper entitled 'Forest Fires,' by Mr. Alfred Gaskill. By impressing the public with some idea of the peril it suffers from forest fires, and the

enormous damage they do, the bureau hopes to induce more effective legislation in suppressing them.

Investigation has shown that, in an average year, 60 human lives are lost in forest fires, $25,000,000 worth of real property is destroyed, 10,274,089 acres of timber land are burned over, and young forest growth worth, at the lowest estimate, $75,000,000, is killed. A special canvass of the country by the Department of Agriculture in 1891 discovered 12,000,000 acres of timber land destroyed by fire. These figures are mere estimates, which fall far short of showing in full the damage done. No account at all is taken of the loss to the country due to the impoverishment of the soil by fire, to the ruin of water courses, and the drying-up of springs. Even the amount of timber burned is very imperfectly calculated, and the actual quantity destroyed is far in excess of that accounted for. Forest fires in this country have grown so common that only those are reported that are of such magnitude as to threaten large communities. The lumbering industry in remote sections of the country may be ruined and people forced to flee for their lives without a mention of the disaster beyond the places near where it occurred.

The fires that burnt this year in Washington and Oregon were uncommon only in the number of lives lost. The burning of logging and mining camps and farm buildings, the loss to the country in the destruction of timber and young tree growth, is of yearly occurrence. Every fall, not only in Washington, Oregon, Colorado and Wyoming, but up and down the Pacific coast and all over the Rocky Mountain country fires burn great holes in the forests and destroy the national wealth. The air of the mountains over hundreds of miles is pungent with the smoke of conflagration, and navigation on Puget Sound has often been impeded by smoke. The following comment by Dr. Henry Gannett, of the U. S. Geological Survey, should convey a fair idea of the damage done in the state of Washington: "In less than a generation two fifths of the standing timber has been destroyed in one of the richest timber regions on the continent, and of the destruction more than half has been caused by fire. Assuming that the timber would, if standing, have the value of 75 cents per thousand feet, not less than $30,000,000 worth has gone up in smoke, a dead loss to the people of the state."

SCIENTIFIC ITEMS.

OGDEN NICHOLAS ROOD, since 1863 professor of physics in Columbia University, one of the most eminent American men of science, died on November 12, in his seventy-second year. We hope to publish subsequently some account of Professor Rood's life and work.

SOME years ago Mr. Hodgkins left his fortune to the Smithsonian Institution to be used for the increase and diffusion of more exact knowledge in regard to the nature and properties of atmospheric air in connection with the welfare of man, the endowment amounting to about $250,000. Part of the fund has been used to establish a Hodgkins gold medal, which in 1899 was awarded to Lord Rayleigh and Professor Ramsay for their discovery of argon. A second award of the medal has now been made to Professor J. J. Thomson, of the University of Cambridge, for his investigations on the conductivity of gases, especially the gases that compose the atmospheric air. An engraving from this medal, made by M. Chaplain, is here given. Professor Thomson has just been appointed the first lecturer at Yale University on the foundation established with a bequest of $85,000 from Benjamin Silliman.

THE degree of LL.D. was conferred on Dr. Alexander Graham Bell at St.

Andrew's University on October 23, on the occasion of the installation of Mr. Andrew Carnegie as rector.—Mr. William Sellers has been nominated for the presidency of the American Society of Mechanical Engineers.—Professor Kohlrausch, president of the Reichsanstalt, has been elected a foreign member of the Swedish Academy of Sciences.

MR. JOHN MORLEY has given the library of the late Lord Acton to Cambridge University. It will be remembered that this valuable historical library of some 70,000 volumes was purchased some time ago by Andrew Carnegie from Lord Acton, who was allowed to retain it until his death. Upon Lord Acton's death Mr. Carnegie gave the library unconditionally to Mr. Morley.—It is announced that the entomological collection of the late John Ackhurst, of Brooklyn, containing some 50,000 specimens, has been purchased for the zoological department of the University of Chicago.—The collection of the birds of Holland, formed by Baron Snouckaert van Schauburg and mounted by Tar Meer, the celebrated Dutch taxidermist, has been purchased by the Carnegie Museum.

A COMMEMORATIVE tablet has been placed on the house at Favières in which Professor A. A. Liébeault was born. It states that he opened a new era in the medical sciences by his discovery of the systematic application of suggestion and induced sleep in the treatment of disease. The tablet was unveiled in the presence of Professor Liébeault on his seventy-ninth birthday.—An effort is being made by the mayor and municipal council of St.-Just-en-Chaussée, Oise, France, to raise a memorial to two famous men who were born in that town, the brothers Haüy-René Just, founder of mineralogy as an exact science, and Valentin, the philanthropist, who founded the first school for the blind.